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QUANTITATIVE INVESTMENT MODELS, ERRORS, AND THE FEDERAL SECURITIES LAWS

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ABSTRACT

This Article provides an overview of the practical and theoretical issues that arise in applying the federal securities laws to quantitative investment models. The Article begins by providing an overview of the model development process, the breadth of data available to asset managers, and the application of model signals to investor portfolios. It then addresses many of the misconceptions that attorneys and policymakers may have about investment models. Importantly, the Article discusses the myths that there are perfect investment models and portfolios; and that models, rather than human beings, manage investor assets. The Article explains that the development of models is regarded as an error prone process; and that models themselves are continuously revised by managers to correct errors and incorporate enhancements. The Article indicates that investment models are properly viewed under the federal securities laws as research used by advisers to support their investment decision-making process. Thus, inevitable mistakes by managers in the development of models or the interpretation of model signals are part of the investment decision-making process, no different than mistakes that occur in the research that traditional managers rely on to make investment decisions. A manager's determination to correct a flaw in model design, or programming, is an investment decision and should be viewed in the context of the larger model governance and portfolio management process. The Article also indicates that quantitative managers and traditional managers are subject to the same legal standards and emphasizes that there is no justification for holding quantitative managers relying on investment models to a higher standard of care (e.g., strict liability) than that imposed on managers relying on traditional research. In this regard, the Article examines relevant SEC precedent and concludes that the template used by the SEC for

trading errors, including reimbursement and disclosure obligations and the role of compliance officers, is not well-suited for investment models.

INTRODUCTION

Almost all modern investment managers rely on some form of "quantitative research techniques"[1] each day to collectively manage many trillions of dollars in assets.[2] Quantitative research techniques can be used to capture and refine information that is either a component of the research relied on by traditional managers[3] or directly incorporated into complex mathematical models used by quantitative managers. Although reliance on quantitative investment models has become widespread in the asset management industry, these models may be viewed with suspicion by regulators and other policymakers. This is due in part to the fact that quantitative investment models and their application by modern asset managers are not well understood by many outside the industry.

Regulators and other policy makers are also confronted with applying dated laws and concepts that do not reflect the reality of modern investing. One of the primary federal laws that governs the conduct of investment advisers who rely on quantitative models is the Investment Advisers Act of 1940 ("Advisers Act").[4] As its name suggests, the law was enacted over seventy-five years ago; in an era in which managers relied on traditional research reports and fundamental analysis to recommend "good" stocks for inclusion in client portfolios.

In recent years, more regulators, including the Securities and Exchange Commission (SEC) and Commodity Futures Trading Commission (CFTC), have begun to focus on technology and the application of quantitative research techniques and models by investment managers. This process has involved

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1. These are also referred to as "quantitative tools" or "quantitative methods."

2. It was estimated that in 2014 there were $76 trillion in assets under management, representing forty percent of the global financial system's assets. *See Policy Recommendations to Address Structural Vulnerabilities from Asset Management Activities*, FIN. STABILITY BD. 1 (June 22, 2016), http://www.fsb.org/wp-content/uploads/FSB-Policy-Recommendations-on-Asset-Management-Structural-Vulnerabilities.pdf.

3. The terms "traditional," "fundamental," and "qualitative" often are used interchangeably to describe non-quantitative managers.

4. Investment Advisers Act of 1940, 15 U.S.C.A. § 80b (West 2016).

rulemaking addressing technology systems, adviser examinations, and industry sweeps, as well as state and federal enforcement actions. It is also evident in the way that regulators have incorporated quantitative research techniques, including the use of big data, for their own internal policymaking and enforcement regimes.

However, the laws and guidance from regulators have not been modernized to embrace advances in technology, portfolio theory, or the use of quantitative tools and models. The learning curve that the SEC has faced is evidenced by recent enforcement actions and examinations of advisers employing quantitative research techniques. Significantly, in 2011, the SEC heralded its "first ever" settled enforcement actions involving errors in quantitative models. Two separate SEC enforcement actions involved a well-known investment management firm that relied heavily on quantitative investment models (the "Firm Order")[5] and its co-founder (the "Rosenberg Order").[6] The actions (together, the "Orders"), announced seven months apart, were based on a programming error in one of the firm's investment models. The respondents settled the actions and neither admitted nor denied the allegations made by the SEC. Notably, Dr. Barr Rosenberg ("Dr. Rosenberg"), the investment firm's research director, and chairman, agreed to a permanent bar from the industry and paid a $2.5 million fine.[7]

Dr. Rosenberg, formerly a professor at the University of California at Berkeley, was a pioneer in the field of quantitative management. He was described by one commenter as, *"the most distinguished and influential quantitative analyst (both academically and professionally) [that the] industry ever produced.*" (Emphasis added).[8] He is widely credited as among the first to trans-

5. AXA Rosenberg Group, LLC, Securities Act Release No. 9181, Investment Advisers Act Release No. 3149, Investment Company Act Release No. 29574, 100 SEC Docket 1126 (Feb. 3, 2011) [hereinafter Firm Order].

6. Barr M. Rosenberg, Investment Advisers Act Release No. 3285, Investment Company Act Release No. 29818, 101 SEC Docket 4053 (Sept. 22, 2011) [hereinafter Rosenberg Order].

7. *Id.* at 5.

8. Bernhard Scherer, *What Quants Can Learn from the AXA Case*, FIN. TIMES (May 20, 2012), https://www.ft.com/content/65a66800-9eb4-11e1-9cc8-00144feabdc0. He also has been referred to as "one of the titans of quantitative investing and research . . . ." *See* Chicago Quantitative Alliance (CQA), *Sound Practice Guidelines for Quantitative Investment Managers, Version:*

form academic theories[9] into practical applications that could be used to manage assets, and was regarded as an expert in risk as a central element of investing.[10]

Unfortunately for him, Dr. Rosenberg also became a pioneer in the SEC's enforcement of securities laws against investment advisers who rely on quantitative models. The SEC's actions involving Dr. Rosenberg and the firm he co-founded, are significant not only because of Dr. Rosenberg's reputation in the industry,[11] but also because they reveal the SEC's attempt to apply laws and precedent established in a different era to modern investment practices.[12] The Orders, along with statements made by the SEC's senior staff in a separate news release ("News Release"),[13] generated controversy and confusion in the investment industry—particularly with respect to the lia-

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2.0, (Working Draft White Paper, June 14, 2014) [hereinafter CQA Working Draft White Paper] (available on request from the CQA). The CQA, along with the Society of Quantitative Analysts and the QGroup, are among the largest professional associations of the quantitative management industry in the United States, though there are many other quantitatively-focused professional associations that can be found in the United States and internationally

9. Among the publications of Dr. Rosenberg were the following: Barr Rosenberg & Walt McKibben, *The Prediction of Systematic and Specific Risk in Common Stocks*, 8 J. FIN. & QUANTITATIVE ANALYSIS 317 (1973); Barr Rosenberg & Andrew Rudd, *Extra-Market Components of Covariance in Security Earnings*, 9 J. FIN. & QUANTITATIVE ANALYSIS 263 (1974); Barr Rosenberg & Andrew Rudd, *The "Market Model" in Investment Management*, 35 J. FIN. 597 (1980); Barr Rosenberg, *The Capital Asset Pricing Model and the Market Model*, 7 J. PORTFOLIO MGMT. 5 (1981); Barr Rosenberg et al., *Persuasive Evidence of Market Inefficiency*, 11 J. PORTFOLIO MGMT. 9 (1985).

10. *See, e.g.*, RICHARD R. LINDSEY & BARRY SCHACHTER, HOW I Became a Quant 34 (2007); SCOTT PATTERSON, THE QUANTS 72 (2010); *see also, From Concept to Function: Converting Market Theories into Practical Investment Tools*, 7 J. INV. CONSULTING 10 (2006).

11. While he determined to apply his knowledge to the actual management of assets, he and other thought leaders who were pioneers in the exploration of quantitative methods and the theory of "risk" are regarded by many with a reverence similar to that of the industry's Nobel Laureates.

12. This Article does not attempt to address all of the statements in the SEC's Orders. It also is not intended exculpate the Firm or Dr. Rosenberg. In fact, the Orders may not reflect all of the information available to the SEC; and both parties may have had additional relevant information or theories that would have been presented had the matter been litigated.

13. Press Release, SEC, SEC Charges AXA Rosenberg Entities for Concealing Error in Quantitative Investment Model (Feb. 3, 2011), https://www.sec.gov/news/press/2011/2011-37.htm

bility of quantitative firms for modeling errors and the obligations of compliance officers. The Orders and News Release were read by many to reflect new SEC policy regarding quantitative investment models, which holds advisers strictly liable for programming errors, and that imposes a new or enhanced obligation on compliance officers to be involved in the oversight of technical protocols designed to prevent a variety of errors in investment models.

While the SEC's actions involved a well-known institutional manager that emphasized quantitative investing, some of the positions announced in the Orders could be applicable to traditional managers that use models or quantitative research techniques to screen for possible investments, or for risk management purposes. In this regard, the precedent established by the Orders also is very significant because it may be cited in future SEC enforcement actions and guide day-to-day decisions by members of the industry and their counsel about compliance with the law. However, as explained in this Article, the Orders do not reflect the manner in which investment models and quantitative research techniques are actually used by most advisers. Moreover, the legal theories expressed in the Orders appear to have been based on prior SEC enforcement actions that are not fully relevant.

This Article explores the differences between mistakes in quantitative investment models, traditional investment management research, and trading errors in the context of the federal securities laws. To add perspective for lawyers and others not steeped in information technology or finance, the Article broadly discusses quantitative investment models, including how models are developed and applied, the control environment for models, and the insights provided by new data sources. While the Article focuses on institutional managers[14]

14. While this Article is focused on institutional managers, at the retail level there has been a growing market for so-called "robo-advisers." Robo-advisers are generally regarded as web-based advisers that use algorithm-based interfaces to determine an investor's goals and provide portfolio management services including stock recommendations, rebalancing, and tax harvesting. Typically, the investor accesses the service by means of an internet interface that includes a questionnaire, covering topics similar to those posed by a traditional retail adviser, in which investors can indicate their risk tolerances, investment horizon, etc. Robo-adviser programs offer various degrees of customization, but generally are discretionary, which

and long-term equity strategies, much of the analysis may be relevant to models used in other contexts.

The Article addresses both the theoretical and pragmatic issues under the federal securities laws that are raised by the growing importance of investment models and quantitative research techniques in modern asset management. These issues include, for example: do models or advisers manage client assets? If a model has errors, does the client portfolio constructed still reflect the manager's intent? Should there be a distinction between an error in a model and an enhancement to the model, or other investment-related information? Is an investment model the same under the law as traditional "street" research?

The primary conclusions of the Article are:

- Investment models are "research" tools used by advisers to support the investment decision-making process. The development of models is an error prone process. Inevitable mistakes by managers in the development of models or the application of model signals are part of the investment decision-making process, no different than mistakes that occur in the research that traditional managers rely on. A decision by a manager to

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means the adviser selects the investments in an investor's portfolio based on his or her preferences. The investor can typically change their risk profile or investment goals, and the adviser offering the services also may provide limited personal counseling and advice. The adviser also may disclose the risk that their models can contain flaws. The services of robo-advisers generally are priced lower than traditional retail advisory services, and require much lower minimum asset levels.

Robo-advisers are registered investment advisers, generally regulated by the SEC. Robo-advisers also have been recommended by Department of Labor officials. *See* Mark Schoeff, *DOL Secretary Perez Touts Wealthfront as Paragon of Low-Cost, Fiduciary Advice*, INV. NEWS (June 19, 2015, 1:24 PM), http://www.investmentnews.com/article/20150619/FREE/150619892/dol-secretary-perez-touts-wealthfront-as-paragon-of-low-cost. But, some have raised questions about whether robo-advisers gather enough information about an investor to meet their fiduciary duty in making a recommendation (i.e., whether they meet their suitability obligation). *See, e.g.*, Policy Statement, Commonwealth of Massachusetts Securities Division, Robo-Advisers and State Investment Adviser Registration (Apr. 1, 2016); *see also* Melanie L. Fein, *Robo-Advisers: A Closer Look*, 7 BANKING & INS. EJOURNAL 174 (2015). *See generally* SEC Investor Bulletin: Robo-Advisers (Feb. 23, 2017), https://www.investor.gov/additional-resources/news-alerts/alerts-bulletins/investor-bulletin-robo-advisers.

correct a flaw in data integrity, design, or programming of a model is also an investment decision and should be viewed in the context of the larger model governance and portfolio management process.

- Both quantitative managers and traditional managers are subject to the same legal standards, including appropriate standards of care and disclosure obligations. There is no legal justification for holding quantitative managers to a higher standard of care (e.g., strict liability) than that imposed on traditional managers. The standards used by the SEC to analyze trading errors are generally not appropriate for examining model errors.
- The discovery of a defect in a model in most cases is simply new investment-related information, like other new information, that is highly contextual and generally should not mandate a specific response. The existence of errors in quantitative models in most cases also should not require disclosure or reimbursement payments to investors.

The Article is divided into three parts. Part I is intended for those who do not have STEM backgrounds or an understanding of quantitative investing. It may not be of interest to readers already versed in the development and application of quantitative investment models. Part I provides an overview of model development the quantitative investment process that is necessary for some to understand the analysis provided in later portions of the Article. Part II offers a brief overview of fiduciary law and relevant SEC precedent, including the SEC's action against Dr. Rosenberg. This Part describes general fiduciary principles developed under trust, contract, and agency law, and even under heightened standards of ERISA. It also discusses the Orders and how they may feed misconceptions about quantitative investment models. Finally, Part III examines the significance of errors in quantitative models and the standards applicable to quantitative managers under the federal securities laws based on the fact that models are correctly classified as "research" used in the investment decision-making process. Part III also addresses general corporate escalation and ethics policies and the role of compliance officers within quantitative managers.

I.
Overview of Quantitative Management, the Application of Models, and Model Governance

With the development of technology and access to vast amounts of information, quantitative research tools have evolved significantly over the past fifty years.[15] Roughly a third of institutional money managers have been identified as emphasizing the quantitative elements of their investment process,[16] and a significant portion of the most successful hedge fund managers recently were categorized as "quantitative."[17] Larger asset managers also frequently offer both traditional and quantitatively-focused strategies that are managed by separate teams. However, almost all modern managers (including traditional managers) rely to varying degrees on some form of quantitative tools and research as part of their investment decision-making or risk management processes.[18]

Quantitative strategies are data driven and designed to capture information from a variety of sources, including pub-

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15. Some believe that the origin of quantitative investing was a 1900 doctoral thesis: Louis Bachelier, *The Theory of Speculation* (Mark Davis & Alison Etheridge trans., Princeton Univ. Press 2006) (1900). Others point to Harry Markowitz, *Portfolio Selection*, 7 J. Fin. 77 (1952). In the last fifty years, Robert Merton, Harry Markowitz, and others significantly advanced the field of applying mathematics to investing. *Id.* Several popular books relevant to quantitative investing include: The Oxford Handbook of Quantitative Asset Management (Bernhard Scherer & Kenneth Winston eds., Oxford Press 2014); Patterson, *supra* note 10; Lindsey & Shachter, *supra* note 10; *see also* Frank J. Fabozzi, Sergio M. Focardi & Caroline Jonas, *Challenges in Quantitative Equity Management*, 2008 Res. Found. Publ'ns. 2 (2008) (providing an excellent overview of quantitative investing).

16. *See* Josef Lakonishok & Bhaskaran Swaminathan, LSV Asset Management, Quantitative vs. Fundamental Institutional Money Managers: An Empirical Analysis (2010).

17. Eight of the top ten earners among hedge fund managers in 2016 fall within the "quant" category according to one publication. Stephan Taub, *The 2016 Rich List of the World's Top-Earning Hedge Fund Managers*, Inst'l Inv.'s Alpha (May 16, 2016), http://www.institutionalinvestorsalpha.com / Article/3552805/The-2016-Rich-List-of-the-Worlds-Top-Earning-Hedge-Fund-Managers.html.

18. Traditional managers frequently rely on quantitative filters to sift through large universes of possible investments to distinguish securities whose characteristics are consistent with their investment strategy, and then supplement the results with a much greater degree of fundamental research, including reviews of balance sheets and income statements, management discussions, factory visits, etc.

lic filings, quotation services, analysts' recommendations, and other forms of information that can be expressed in numeric form. Quantitative managers emphasize that they offer a "scientific approach" to investing and quantitative investing has been described as "the automation of rationality."[19] The benefits of quantitative investing versus the approach taken by traditional managers are generally believed to include the capacity to screen large amounts of information to identify investment opportunities that are consistent with core elements of an investment strategy; the ability to implement a more disciplined, systematic investment process (removing a large degree of human cognitive bias); the ability to back-test theories;[20] greater transparency; and risk controls that may lead to more stable returns over time.[21] Moreover, from a business perspective, the scalability of models means that the number of professional staff within a quantitative manager may be smaller relative to traditional managers.

The methods used by quantitative managers vary tremendously (e.g., they generally include fundamental financial statement analysis, factor analysis, sector rotation, technical indicator analysis, and rules-based analysis).[22] The degree of automation in the quantitative investment process also can vary significantly among managers. Some quantitative managers, for example, employ a hybrid process in which they supplement model output with traditional research, while others have more automated functions. Within the quantitative community, some have roughly classified the groupings as: pure

19. Brett Steenbarger, *Reason And Rationality: The Psychological Keys To Investing Success*, FORBES (July 24, 2016, 7:49 AM), https://www.forbes.com/sites/brettsteenbarger/2016/07/24/reason-and-rationality-the-psychological-keys-to-investing-success/#465cab7c12a1.

20. "Back-testing" is a process of evaluating a theory or model by applying it to historical data. In some cases, managers use teams different from those developing the models to perform the back-tests.

21. The investment approach used by traditional managers, however, is thought to have the advantage of being more flexible in terms of more rapidly accommodating changes to investment paradigms, or information regarding market conditions or individual stocks.

22. Although tremendous variation may exist among quantitative approaches, quantitative management is viewed by some as a distinct investment segment because managers may rely on similar historical data, research, and investment theories, which can cause their returns to be highly correlated.

quant/systematic, quant with discretionary views on single stocks, and quant with broad discretionary views possible.

The life cycle of investments and the time horizons for strategies employed by quantitative managers range from short-term trading strategies (e.g., nanoseconds) employed by high frequency traders, to "passive quantitative" index strategies or "semi-passive/semi-active quantitative" index strategies (or "alternative index" products, such as "smart beta" ETPs[23]), in which the components are adjusted on an annual or semi-annual basis in light of simple transparent rules (e.g., the Russell 1000 Value Index) or more complex rules-based criteria (e.g., the FTSE RAFI US 1000 Index);[24] to long-term buy-and-hold value strategies. And, while some of these investment strategies are generally unique to quantitative managers (e.g., market neutral, 130/30, risk parity, portable alpha, alternative beta and smart beta),[25] others follow the same basic investment philosophies pursued by traditional managers (e.g., growth, value). Consistent with their strategies, managers may trade intraday, daily, weekly monthly, quarterly, semiannually, or over some other period.

Generally, models themselves are merely a set of mathematically-based rules designed to test a theory or to perform a function. A model is typically expressed and implemented through computer programming. As noted above, almost all modern managers, including traditional managers, use some form of quantitative research techniques to refine their research. Many use a variety of models in their risk management

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23. An "ETP" is an "exchange traded product." These generally are index-based mutual funds that are traded on exchanges.

24. Index funds may be either fully-replicating or optimized. Fully-replicating index funds hold all the securities in an index in the same proportions of the index. Optimized index funds do not hold the entirety of the index positions in their portfolios, but maintain a subset of representative index securities that matches the index's key risk criteria as closely as possible. Index funds may also use index derivatives to maintain index exposure or for other purposes.

25. A deviation from traditional indices offered by quantitative managers is "smart beta" or "alternatively weighted index investing," which has been referred to as the intersection between active and passive investing. In these strategies, the index sponsor attempts to improve on the capitalization-weighting approach to market exposure ("beta") in traditional indices by emphasizing fundamental criteria, such as book value, earnings and sales, or other "factors," such as a security's price momentum or volatility.

discipline (for example, to stress test[26] the risk or liquidity of a portfolio). Or, they may build or license models that help them analyze and forecast the future profitability or cash flow of a company, execute trades, or simply to screen a large number of securities to find those with defined characteristics that will be subject to further analysis. Traditional research providers may also use quantitative techniques to develop views that are reflected in their research reports.

Quantitative managers use models as "decision support tools" to select securities for investment and assemble those securities into a portfolio that observes disciplined risk parameters or controls. A common misconception, however, promoted perhaps too broadly for marketing purposes, is that quantitative management is a passionless process that avoids all investment mistakes attributable to human judgment and emotion. While this is generally true, relative to traditional management, there may also be a tendency to view quantitative models as entirely mechanistic or robotic tools that is divorced from the exercise of human discretion in the management of portfolios or the model development process.

As discussed throughout this Article, creating a detailed investment model and managing actual portfolios involves numerous subjective decisions that require human judgment. These decisions relate not only to the development of the model itself (including the underlying research, selection of data, monitoring of output, correction of errors, and enhancements), but also establishing the return objective for a strategy and determining the level and types of risks that will be taken within a portfolio to achieve that objective. Like all decisions made by humans, the wisdom of those many decisions will only be clear with the benefit of hindsight (much like investment decisions made by traditional portfolio managers).

The remainder of Part I discusses types of models; the manner in which models are developed and enhanced, including the controls over model development; the way model out-

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26. "Stress testing" or "scenario analysis" is the process of examining the possible effect of extreme market conditions on a portfolio. For example, managers may consider events, such as significant interest rate movements, to measure their potential impact on portfolio performance. They also may consider micro-economic events.

put is applied in the context of a portfolio; and the important role of ongoing monitoring by the asset manager.

A. *Investment Philosophy, Common Types of Models, and Their Application*

1. *Model Output and Portfolios Reflect Core Beliefs*

Quantitative investment managers typically build substantially all of their investment process around a series of models that are consistent with their core beliefs about investing. Elements of models are frequently based on published academic research that attempts to identify factors that may provide insight into investment performance over time.[27] Quantitative models used as the basis of equity portfolio management often embody a basic investment philosophy—such as the belief that better performance can be obtained by owning stocks with low price-to-earnings ratios ("value"), stocks with high earnings or revenue growth ("growth"),[28] or stocks that combine value and growth ("growth at a reasonable price," often referred to as "GARP")—that can be applied to a variety of equity seg-

27. Ideas may be taken from academic research in unrelated areas of science, such as social studies or physics. Managers also may seek insights from "artificial intelligence" or "machine learning." Models using "cognitive technology" attempt to find rules and patterns that are not supported by fundamental academic research. While these methods have been used in the investment industry, they also are used in other non-financial disciplines, such as e-marketing, health care, and genomics. Research has shown that these methods can produce demonstrable improvement in insights. However, there is concern that, like investment decisions made by humans, the full rationale for their output may not be apparent in all cases—with the possibility that they may go awry if not supervised. *See* David Schatsky, Craig Muraskin & Ragu Gurumurthy, *Demystifying Artificial Intelligence: What Business Leaders Need to Know About Cognitive Technologies*, DELOITTE U. PRESS (Nov. 4, 2014), https://dupress.deloitte.com/dup-us-en/focus/cognitive-technologies/what-is-cognitive-technology.html (discussing the growth in the application of artificial intelligence since 1950).

28. Firms using value-oriented, fundamentally-based factor models may seek stocks that appear to be undervalued in light of their current market price relative to other stocks with similar earnings or financial factors. In contrast, investors emphasizing growth or momentum look for companies whose revenues and earnings are expected to increase at a rate that is faster than other companies in the same industry.

ments (large cap U.S. stocks, small cap U.S. stocks, non-U.S. stocks, etc.)[29]

2. *Types of Quantitative Models*

A common misconception is that quantitative managers rely on a single "model." In fact, there are a variety of models used by each quantitative manager. Many firms employ tens, if not hundreds, of models in their investment management process. The models usually fall into two broad categories—"predictive models" and "risk models." While predictive models attempt to forecast future returns or market conditions, risk models are concerned with exposures to risk—often measured in terms of correlation of return to a benchmark index (the risk-free measure). These categories are blurred and not mutually exclusive. Many predictive models, for example, are concerned with picking securities or constructing portfolios within a set of risk parameters, and are therefore built around a risk model.

a. Factor Models

Although, as suggested earlier, there are different types of models, quantitative managers frequently use factor models. In the context of securities, a "factor" is any characteristic that is important in explaining the return or risk of a security or portfolio.[30] A factor can be defined differently, depending on who is doing the defining, and may use multiple different data sets. Factors commonly emphasized are quality or value, size, volatility, and momentum. The defining characteristics of a factor, such as value or quality, may be the subject of intense academic research[31] and debate, as is whether (and if so, why)

29. Institutional separate account managers, private fund managers, and mutual fund managers generally are selected to manage a "sleeve" of a larger portfolio in a specific asset class, based on their investment style. Their performance typically is measured relative to a chosen public benchmark or custom benchmark composed of a peer group of other managers with similar mandates and investment styles.

30. Models based on "Fama-French" factors use either three, four, or five factors, depending on which version of the theory is being applied. However, some models use substantially more factors.

31. A simple search of the internet will reveal that there are a large number of financial and technology journals, and working papers, published each year by well qualified academics and practitioners that discuss almost

the factor enhances portfolio performance and the best way to capture that factor. Moreover, within these broad categories, there may be many measures (e.g., hundreds) that are used in an attempt to better capture a factor. For example, "value" is a factor but it can be defined as price-to-book, price-to-earnings, price-to-sales, price-to-cash flow, and other measures, or various combinations thereof.

Multi-factor models are used by quantitative managers to stress combinations of factors, often explored in academic literature, that the manager believes will enhance risk-adjusted returns. Some factors are security specific (e.g., value, growth, size) while others are common factors (e.g., exposure to interest rates, currency fluctuations) and typically affect all or most companies, or all of those within specific industries.[32] Factors used in models are typically based on historical data, but they may also be used as the basis for seeking forward-looking insights, such as the likelihood of broader economic effects on an industry, sentiment changes revealed in the qualitative[33] opinions of traditional sell side analysts[34] as well as

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every aspect of model development. However, the publicly available information is dwarfed by the proprietary research that is not published.

32. For example, the returns of a specific stock may be based both on its individual characteristics, such as price-to-earnings ratio or balance sheet leverage, as well as its asset class (e.g., small cap or mid cap) and its location in a particular industry or industry segment.

33. The terms "quantitative" and "qualitative" refer to kinds of data. Quantitative data often is described as being expressed as a number, while qualitative data is expressed as a word or words (e.g., "yes"). In addition, "subjective" data generally is regarded as data that reflects personal opinion or judgment. In contrast, "objective" data is "external to the mind" and concerns the precise measurement of things or concepts that actually exist. Quantitative managers often attempt to convert qualitative and subjective information into numbers that can be incorporated into their models. A similar concept is expressed as "structured" (numeric) versus "unstructured" (qualitative) data sets.

34. The "sell side" refers to brokers that execute trades, while the "buy side" refers to asset managers that place the buy or sell orders with brokers. Managers value the sell side analysts' opinions as a measure of forward-looking sentiment that may balance historic data. Many quantitative firms have traditionally relied on sell side analysts' published (including electronically) buy, sell, and hold recommendations, as well as long and short-term earnings forecasts, and changes in earnings consensus among analysts prior to earnings announcements. The views of these analysts about the management of companies, the companies' competitive positions, etc. also may be reflected in qualitative information in analysts' notes, discussions in telephone

traders,[35] or the aggregate short positions of hedge funds. Moreover, some models are "passive," in that they emphasize static exposure to factors over a longer period of time, while others are "dynamic" and the manager may alter the weightings of factor exposures to take advantage of a variety of recent economic or market variables.[36]

Managers also may employ multiple models and assign weights,[37] both to individual factors used in a model and to the model itself. The factors used by managers and their weightings also may vary over time based on the manager's research and ongoing assessment of the strength of the signals produced by a factor within the adviser's mandate, as well as other variables. An individual company, for example, may be decomposed by a quantitative manager into hundreds of inter-

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calls, meetings, and investor conferences, among others, and converted into numerical form that can be factored into models. The views of sell side analysts either can be acquired from third-party vendors, or advisers may conduct their own broad-based surveys.

35. "Alpha Capture" programs, which quantify the sell side's "best trade ideas" (based on the ideas of sales traders rather than research departments), are an example of new judgmental data that some quantitative managers have employed to gain insights into price performance. The individual trade ideas of a firm (like analysts' estimates), or the basis for the ideas, may not provide significant insight into stock performance—except over a period of time and in combination with other factors that provide a mosaic of information about individual stocks. Like analysts' estimates, they are an attempt to quantify market sentiment about a security. That information may or may not offer insight with respect to an investment, but may explain some degree of price performance across a range of investments. Alpha Capture programs were the subject of an SEC enforcement sweep in 2011 because of concerns that potentially market moving information was not being provided to all investors at the same time, raising insider trading concerns. *See, e.g.*, SEC Sweeps Alpha Capture Platforms, Integrity Research Associates (Apr. 19, 2011), https://www.integrity-research.com/sec-sweeps-alpha-capture-platforms/.

36. The emphasis of specific factors in a transparent, rules-based strategy underlies the "Smart Beta" ETPs that have proliferated in recent years as an alternative to traditional index strategies (and are expected to exceed one trillion dollars in assets by 2020). *See, e.g.*, Teresa Rivas, *Smart Beta ETF Assets Will Reach $1 Trillion By 2020: BlackRock*, BARRONS (May 12, 2016, 3:02 PM) http://www.barrons.com/articles/smart-beta-etf-assets-will-reach-1-trillion-by-2020-blackrock-1463079755.

37. The numerical weighting of factors in a model, as a percentage, is entered into "factor tables."

nal metrics,[38] such as financial ratios and exposures based on the source of their revenues (e.g., industry, country) and exposure to expenses related to production and material prices, as well as access to capital.[39] Or, the factors included by a manager may be related to market sentiment unique to a particular issuer (e.g., analysts' estimates revisions or "alpha capture").

The goal of a manager using factor models is to identify those factors that are consistent with its investment strategy and provide a correlation benefit when combined correctly with other factors. Using too many factors may dilute the strength of signals that offer the most insight. Thus, the selection of precise factors, and the related data sets, to use in a model are a strong focus of managers. Moreover, a portfolio's overall exposure to factors frequently is more important to the manager than individual stock positions.

There are an infinite variety of models among managers that emphasize the same factors. Even when managers emphasize the same data, they may process it differently. For example, in the case of managers emphasizing growth factors, such as trends in analysts' earnings estimates, a firm's research may

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38. Some firms decompose balance sheets and income statements and do not use standard industry classifications of sectors and segments for risk purposes, and also may not classify a particular security as belonging in only one industry sector or segment in the same fashion as the benchmark index for a strategy. Instead, they may assign stocks to "clusters" or other groupings. For example, depending on its product line, a single company may have exposures that are similar to other monoline companies that operate exclusively in sectors such as retail electronics or communications. Fundamental databases available to managers also group "baskets" of companies based on their exposure to international markets, which may be a more relevant measure of revenue exposure and country risk. Thus, multiple fundamental factors can be combined to form composite factors, deconstructed into multiple sub-factors, and further divided by time, industry, or season and compared with macroeconomic data, including interest rates, census data, social data, or industry-specific information. This means that managers in some cases may view their exposures differently than clients or their consultants

39. There is significant debate about relevant factors. *See generally* Gregory Connor, *The Three Types of Factor Models: A Comparison of Their Explanatory Power,* 51 FIN. ANALYSTS J. 42 (1995); Eugene F. Fama & Kenneth R. French, *A Five-Factor Asset Pricing Model*, 116 J. FIN. ECON. 1 (2015). *Cf.* Clifford S. Asness, Andrea Frazzini & Lasse H. Pedersen, *Quality Minus Junk* (Working Paper), https://ssrn.com/abstract=2312432.

suggest that an individual sell side analyst, or firm, is better at picking long positions versus short, or technology stocks versus healthcare stocks.[40] Firms may also weight the importance of estimates revisions in their overall models differently (e.g., five percent or eleven percent). And, even if two managers rely on the same factor, they may weight the currency of the data differently (e.g., emphasizing the past quarter versus one year). Accordingly, the information they receive is not normally a straight-through input into an investment decision. Instead, the information may constitute only a single element, among many, considered in a model. Moreover, the same manager may use different models (or weight factors differently) from industry-to-industry, based on capitalization range, or from country-to-country in international strategies. For example, different factors may be emphasized in a model used to select technology stocks than utility stocks, or in Chinese companies versus German companies.

Within the broad class of factor models, the three major categories of "predictive" factor models are "fundamental," "macroeconomic," and "statistical." Fundamental factor models analyze and seek to forecast performance based on an issuer's underlying financials or other metrics unique to that issuer, while macroeconomic models seek to forecast performance based on the effect of factors such as employment, consumer sentiment, capitalization, inflation, and interest on portfolio holdings.[41] These models are based on the fact that

40. The existence of the collective, consensus views, rather than the subjective reasoning of the individual analyst, is believed to contain the most insight in terms of explaining price movements. However, some managers also test the strength of signals from individual sell side analysts' earnings forecasts, and their market moving effect (e.g., "herding" or "leading"), as a predictor of price performance, and may differentiate the different types of signals within their models. *See, e.g.*, Rick A. Cooper, Theodore E. Day & Craig M. Lewis, *Following the Leader: A Study of Individual Analysts' Earnings Forecasts*, 61 J. FIN. ECON. 383 (2001). In the past, the views of individual sell side analysts were sometimes communicated to favored brokerage clients prior to their public release. This practice, commonly referred to as the release of "whisper numbers," was thought to raise "insider trading" concerns, and appears to have been discontinued. However, unlike traditional insider trading cases, the views of a single analyst or any other individual piece of information may only be one of many inputs in a manager's models that lead to an investment decision.

41. Managers emphasizing factors may use either a "top-down" or "bottom-up" approach. Top-down managers emphasize broad international and

the returns of individual assets are often influenced by the market itself, including broad economic events. Statistical factor models use statistical techniques to identify factors not specified in advance that may offer insight into an issuer's performance or a macroeconomic event.

b. Risk Models

Quantitative management is regarded as a risk-controlled[42] process with portfolios managed around considerations of risk budgeting, market environments, and investment horizons—as well as a multitude of overall characteristics or exposures (e.g., industry, sector, growth, value) that the manager wishes to maintain. Managers generally attempt to achieve the highest returns relative to their benchmark, based on the level of risk they or their client is willing to assume. The inclusion of uncorrelated assets, wherever possible, is believed to provide the most stable returns over time.[43]

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national economic indicators; such as GDP growth rates, inflation, interest rates, and exchange rates, and then keep refining their research in an attempt to select the best investment opportunities in an industry sector or segment that they believe are optimal. A bottom up manager focuses first on identifying companies that present favorable investment opportunities, regardless of their industry sector or segment.

42. The term "risk" when used in investment management is not a predictor of absolute returns. The returns of a strategy in most cases are measured against a relevant benchmark. Risk is expressed in actively managed portfolios as the volatility of returns versus that benchmark. The benchmark itself may not be highly volatile. In passively managed portfolios (e.g., index funds) risk is referred to as "tracking error." Thus, "risk" used in investment management may not be the same concept as "risky." "Risk premia" refers to the amount of excess return that an asset must offer over a less risky asset in order to induce an investor to own it (e.g., an asset whose returns are less volatile versus an asset that is more volatile).

43. Academic research suggests that generally higher return expectations require higher exposures to risk. However, some of the risk may be reduced through diversification. Modern portfolio theory is based on the notion that each asset in a diversified portfolio should be selected based on the way it is expected to perform relative to every other asset—rather than in isolation. *See generally* HARRY MARKOWITZ, PORTFOLIO SELECTION: EFFICIENT DIVERSIFICATION OF INVESTMENTS (Yale University Press 1971) (1959); Markowitz, *supra* note 15. William F. Sharpe developed the Capital Asset Pricing Model (CAPM), which concludes that some risk may not be diversified away. *See* William F. Sharpe, *Capital Asset Prices*, 19 J. FIN. 425 (1964). Markowitz and Sharpe received Nobel Prizes for their seminal work.

Risk models contain two components: (1) stock specific risk and (2) common factor, or systemic, risk. "Common factor,"[44] or "systemic," risk includes capitalization, geographic and industry exposures, and volatility, among others. "Stock specific," or "idiosyncratic," risks are those unique to a particular investment. In terms of overall risk, systemic risk usually explains most of any tracking error that a model has versus its benchmark. However, firms normally have target exposures to industries or segments that they wish to retain in a portfolio in light of their benchmarks, which are expressed as active exposures and may be either positive (overweight) or negative (underweight).[45]

In theory, when assets are not directly correlated (i.e, have a low "covariance"),[46] their prices will not move completely in tandem. Thus, while some investments are underperforming during a specific period, others will exceed their historical performance. A given set of assets will have many different outcomes that are "efficient."[47] The choice of

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44. "Common factors" are those shared by a group of securities that influences their returns. For example, Ford and General Motors may be subject to some of the same risks—those shared by others in the auto industry. However, all assets in a portfolio may be affected by market risk and become correlated during periods of crisis. Thus, there may be other more significant influences on a portfolio that diminish "common factor risk" during certain periods. *See, e.g.*, Ioana Moldovan, Stock Markets Correlation: Before and During the Crisis Analysis Theoretical and Applied Economics 111–22 (Vol. XVIII, No. 8, 2011):

> Financial crises are characterized by sudden and simultaneous materialization of risks that in periods of normality seemed independent. As a result, the opportunities of risk sharing are significantly reduced just when they are needed the most, and that can cause a substantial threat to the global financial system.

45. It may be difficult to implement a manager's investment strategy in particular segments or industries, because those industries or segments do not generally include securities that are reflective of the manager's investment philosophy. For example, a manager may be constrained to own utility or technology stocks, even if there are not a lot of stocks in those industries that reflect its investment philosophy. However, to avoid risk relative to a benchmark (i.e., not having exposure consistent with benchmark weightings), a portfolio manager may use models specifically developed to select stocks in these segments and industries.

46. Covariance is the correlation of price movements between assets.

47. The optimal balance between the return objective of a portfolio and the level of risk acceptable to the manager or its client ("risk budget")—in terms of deviation from a benchmark and the desired returns—is referred to

which is best is solely a subjective decision about return objectives and risk tolerance. However, as suggested earlier, correlations are not stable and frequently change over time. Notably, many uncorrelated assets or factors may become highly correlated during periods of market volatility, diluting the benefit of holding uncorrelated assets.

c. Optimizers

In addition to predictive factor models and risk models, virtually all quantitative firms employ "optimizers." Optimizers are models used to manage portfolio and trading decisions. An optimizer is a model, designed to reduce risk, that embeds specialized math which helps identify the best solution for a problem based on multiple variables.[48] In investment management, an optimizer often analyzes the historic correlations of price movements between one stock, industry segment, asset class, or market, and another over a period that represents the investment horizon of the manager.[49]

Investment managers constrain optimizers in many different ways. For example, an optimizer would suggest ideal portfolio weightings given a number of constraints such as limited turnover, acceptable deviation from benchmark on certain risk measures, etc. An optimizer may also be calibrated by a portfolio manager to incorporate internal or client-imposed restrictions, as well as to minimize certain types of deviations ("active risk") versus a benchmark. The latter may include limits on the universe of permitted investments (e.g., large cap U.S. only), limits on number of investments, limits on stock or factor concentrations, limits on turnover, or limits on short exposures and active exposure to industries. For example, if a benchmark index has a weight of fifteen percent in a particular sector, the optimizer may limit the portfolio's exposure to a range of thirteen to seventeen percent. Similar constraints may be imposed on individual security positions,

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as the "efficient frontier." The efficient frontier is a mix of chosen assets that provides a level of return that can't be improved without changing the level of risk tolerance.

48. *See generally Portfolio optimization*, Wikipedia, https://en.wikipedia.org/wiki/Portfolio_optimization (last updated May 25, 2017).

49. *Id.*

d. Non-Investment Software

Managers also often use software applications for reasons other than making investment decisions. For example, managers, including traditional managers, may employ models or use software systems for order management or compliance purposes. Trade execution models are sometimes referred to as "non-alpha generating models." However, the algorithms responsible for trade execution may also contribute to portfolio performance by minimizing market impact of transactions and the total cost of order execution, and in some cases, may actually be designed to generate "alpha." Compliance software also may be used to assure that orders do not result in regulatory violations or transactions that are inconsistent with client-imposed investment restrictions, among other things, or to surveil for breaches of compliance policies.

3. *Model Output and the Investment Process*

Even when firms are identified for their quantitative style, in many cases portfolio managers, or teams, are assigned responsibility for individual client portfolios. These portfolio managers frequently are highly skilled professionals[50] and may serve as the client interface for investment-related matters. Depending on the adviser, the portfolio manager may exercise discretion in overseeing the application of a particular model, or models,[51] to those portfolios—and be held accountable for performance results. For example, portfolio managers often have flexibility in calibrating the way a model is applied in the context of an individual portfolio and interpreting model signals. They also may impose limits (based on client instructions) on the purchase or sale of particular securities, or types of securities, and adjust models based on the amount of risk that the client or manager is willing to assume in order to achieve returns.[52] In addition, depending on the adviser, a portfolio manager may have the authority to override a

50. In larger organizations, portfolio management requires a separate skill set than model development. As noted earlier, often portfolio managers have MBAs or other advanced degrees, and many have qualified for the CFA designation.

51. Portfolio managers may have an inventory of models that they can choose from and apply in connection with an investment decision.

52. *See infra* Section I.A.3.c.

model's output if not acceptable, or traders may have the authority to effect trades in comparably ranked substitution candidates (or "equivalents") in certain circumstances. In this context, models are used by portfolio managers as a decision-support tool to achieve a client's investment objectives.

a. Stock Selection

In general, decisions to buy securities or sell securities are equal components of portfolio management. Purchases or sales of securities for a portfolio may result from "flows" attributable to cash contributions or withdrawals, dividends, or the running of particular models that suggest new transactions. In addition, risk management considerations (e.g., controls on individual position sizes or factor exposures) and periodic rebalancing also may result in reducing some positions and enhancing or acquiring others.

Depending on the model, the output may be a list or grouping of recommendations to accumulate or sell positions for each portfolio. For illustrative purposes, managers will often refer to model output as signals that are grouped in rankings expressed as deciles or quintiles. These broad decile or quintile ranking groups within an industry or segment usually facilitate the substitution of one similarly ranked stock for another to meet the unique requirements or circumstances for each portfolio, without significantly changing the expected return or other characteristics that the manager considers desirable.[53] The portfolio manager, or investment team, may have discretion to invest from among similarly ranked stocks, and to adjust weightings accorded to a specific stock based on factors other than the model's estimate of their projected relative price performance.[54] Traders also may have the authority to effect trades in comparably ranked substitution candidates in certain circumstances.[55]

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53. Some managers believe, for example, that there is very little discriminatory effect between a stock ranked 100 and one ranked 90 by their models.

54. Insight with respect to "specific stock selection" is believed to be difficult to attain and often only provides a narrow edge. Managers anticipate that a high percentage of individual stocks they select may not perform fully as anticipated.

55. For example, if the trader is having difficulty executing a trade because the asset is not available in the market, the spreads have become too wide, or a client's instructions preclude a trade in that security.

The portfolio manager's review of potential transactions can consist of a more traditional overlay, which uses a hybrid approach (involving discussions with research analysts), or a more simple "sanity check" to detect blind spots that are not reflected in historic data relied on by the models, such as a merger announcement, news that a company is under investigation by a regulatory authority, or that the CEO has unexpectedly departed. Unlike their traditional brethren, portfolio managers at quantitative firms are less likely to be familiar with information about a company such as products or product pipelines, or have independent views about management quality. However, subjective views about an individual company may be encapsulated in analyst recommendations or another data point captured by a model.

The portfolio manager also may make decisions regarding the value and size of the purchase, and may determine whether the purchase would breach any internal guideline relating to number of holdings in a portfolio, risk exposures, or client restrictions. In addition, as suggested above, the portfolio manager or investment team may consider information from the trading desk and elsewhere about liquidity in the marketplace (e.g., "street talk" or "chatter"), market impact, possible internal crosses, and related implementation costs that is in addition to the information that is considered by models.[56]

The portfolio manager, or investment team, also may use discretion when the output of a model is not consistent with expectations. For example, the portfolio manager may adjust inputs, choose among different models in the firm inventory, and do multiple runs of a model until he or she is satisfied

56. Portfolio managers also may receive liquidity estimates for each recommendation, showing the days it would take to accumulate or liquidate a position without influencing the market. Liquidity screens and "hurdle rates" often are used to determine whether the transaction costs associated with buying and selling make sense based on potential incremental improvements in alpha. For example, if trading costs for one security may absorb a significant portion of its expected alpha over the projected life of the investment, a portfolio manager may use substitution candidates with lower trading costs and comparable projected returns. Implementation costs (including commissions as well as market impact) may dictate trading strategies (e.g., active versus passive) and also may limit the total assets that a manager is willing to accept in an investment strategy (this may be particularly true in a strategy that focuses on less liquid assets).

with the results before signing off on any trades.[57] Finally, orders may be subjected to manual or automated pre-trade compliance controls (e.g., individualized client investment restrictions) and the timing and completion of a trade also may depend on market conditions, as well as the immediacy required by the strategy and amount of assets being purchased or liquidated (which often effects the amount of transaction costs as well as the manager's sensitivity to those costs).[58]

b. Monitoring Portfolios

Managers with long-term investment horizons may anticipate holding their investments for periods of a year or more. However, almost as soon as individual stocks are selected, changes in price, new market information, and financial reports may alter their desirability according to the criteria of a model. For example, as a result of daily price movements, earnings forecasts or recommendations, quarterly reports, and changes in analyst recommendations, the rankings of individual securities—both in absolute terms and in relation to other companies in the same industry—are continually changing.[59]

Long-term managers do not adjust their portfolio based on every piece of data that becomes available. In fact, one of the key decisions in a model-driven portfolio is how frequently to re-run the methodology to see if there has been material drift. Models may be run only periodically based on scheduled

57. For many managers, because models are only run periodically, trading is not an everyday event, but occurs on a weekly, monthly, quarterly, semi-annual, or another scheduled basis. Once the portfolio manager has made an investment decision, that decision is then communicated to the trading desk, commonly in the form of a trade list provided early in the day. Often, trade lists are expressed as targeted percentages of a portfolio versus current positions and include reductions, liquidations, enhancements, or acquisitions. For example, an existing position may be 2.34% of the non-cash holding in a portfolio targeted to 1.75%, or a new acquisition may presently be at 0% targeted to 2.00%.

58. Similar considerations may occur when liquidating a position, but in many cases the portfolio manager may also take into account the tax consequences of selling one substitution candidate versus another.

59. As a very simple example, a two percent position in a stock may become a three percent position if its price appreciates by fifty percent. The same price appreciation would affect the concentrations of the portfolio in the sector (or factors) represented by the stock, as well as the capitalization of the company (shares outstanding times price) and the average capitalization portfolio (e.g., mid cap versus small cap).

rebalancing or the regular release of significant new data in the market, such as quarterly reports; or, they may be run on an ad hoc basis if there are significant changes to an asset or to macroeconomic factors. In "smart beta" methodologies, for example, everything is allowed to drift for defined periods and then is rebalanced. Thus, the characteristics of individual stocks within a portfolio, as well as the portfolio as a whole, are expected to vary over time.

Because of the dynamic nature of stock holdings, portfolios are constructed with the understanding that external influences will cause their characteristics to vary within a range acceptable to the manager. As suggested earlier, in most cases there is no single "model" portfolio, there are no specific security holdings, and there is no precise factor exposure necessary to effect a manager's investment intent or strategy. No portfolio is perfect and because of the transient nature of markets and holdings, management decisions are often not static.

Managers frequently look at the overall portfolio performance, and whether a portfolio is achieving its objectives, rather than worrying about which individual stocks contribute what to portfolio performance. Within the same general investment objectives, style, and investable universe (based on client benchmarks, i.e., "tradeables"), however, there are an indefinite number of differing, unique portfolios (in terms of stock composition) that can be constructed—with each portfolio designed to observe specific investment constraints and restrictions, while possessing similar exposure levels to key factors that are statistically consistent with a firm's investment beliefs and strategy.

Even when a firm emphasizes stock selection, the precise individual stocks may matter less than ranges of stocks that possess factors that the manager deems to be important. As long as, on average, the chosen stocks, in aggregate, outperform their benchmark, within the desired level of risk, a model may be deemed successful. Thus, depending on the manager, two portfolios with similar objectives and risk tolerances may have substantially the same holdings, or entirely different holdings, and still be managed over time in a manner consistent with the manager's core beliefs and its clients' investment objectives.

Low or moderate turnover strategies used by long-term managers are designed to minimize transaction costs and ac-

commodate changes in investment characteristics over an investment cycle, with the result that individual positions and exposures are maintained by the manager if it determines that they are within an acceptable variance in light of the manager's investment approach.[60] For this reason, many managers use asymmetric entry and exit points—buying stocks ranked in the ninth or tenth decile and then selling if they drop below the seventh or eighth decile. Portfolios also may be rebalanced on a regular basis in light of hard and soft position limits or risk exposures, and may be subject to investment guidelines or client restrictions.

Firms monitor target exposures to factors as changes occur in portfolios. Portfolio managers, for example, often have dashboard windows that reveal account concentrations and exposures across many different dimensions on an intraday basis. These dashboards may be highly detailed and offer not only segment and sector concentrations relative to a benchmark, but also exposure to a host of factors like beta, volatility, and liquidity. Relative and absolute performance of each portfolio normally is reviewed by individual portfolio managers (or investment teams) in light of benchmark exposures to determine whether a portfolio is tracking its benchmark and being managed in a manner that is consistent with the manager's core investment philosophy, taking into account investment objectives.

In larger firms, separate risk teams also may monitor client portfolios on an ongoing basis to detect unwanted risk and adherence to investment guidelines (discussed below), often using tools that are independent from the models they rely on to make investment recommendations. For example, they may use independent or third-party risk analytics to examine whether each portfolio has the desired risk profile and whether the performance of the portfolio over time is tracking its benchmark or performing as the manager anticipates. They also may meet regularly with senior management and portfolio managers or investment teams to discuss risk exposures.

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60. For this reason, newly funded portfolios may contain different investments than existing portfolios. Similarly, during the process of transitioning a portfolio from one manager to another, in order to limit transaction costs, the new manager may accept some existing positions that are compatible with its investment strategy, but use cash to fund acquisitions with higher projected alphas.

These reviews by portfolios managers, and risk teams, may alert the adviser to whether there are any tactical blind spots or aberrant signals that are red flags and should call into question a model's output or suggest that a portfolio is not being managed in a manner that is consistent with the manager's investment strategy. Based on these reviews, which can be simple or extremely sophisticated, managers may make decisions to rebalance portfolios or intervene to improve, or recalibrate, elements of a model that are not working as anticipated. For example, portfolio managers or risk teams may adjust the portfolio optimization process to incorporate information relating to market events not yet captured in the manager's model, and research may be initiated to enhance or improve a model.[61]

c. Rules, Investment Guidelines, and Exceptions

As discussed earlier, managers also may employ simple rules, guidelines, or constraints, such as sector, asset weight, or turnover constraints[62] that are intended to reduce risk (but which also may limit returns). These investment guidelines may, in some cases, also be mandated by a client.[63] Investment guidelines frequently are created through a collaborative process between clients and portfolio managers. Clients, for example, may mandate factor neutrality, the degree of risk a man-

61. As discussed later, industries that are experiencing trouble may be valued cheaply by a model and therefore look attractive to models that are value-oriented. Because of the data-based process used by quantitative managers, models will be driven to overweight stocks in an industry that appears relatively cheap in light of historical norms. Thus, these stocks or industries which are "cheap for a reason" may be a "value trap." To compensate for the blind spot in a model, a portfolio manager or team may put constraints on the optimization process so that the portfolio has no more than a neutral exposure relative to the benchmark weighting, with the result that assets that otherwise would have gone to that sector will be allocated to other sectors where the manager has more confidence that its investment process will be effective.

62. Turnover constraints may be reflected in "flip flop" controls that are designed to avoid excessive buying and selling in portfolios that may be due to the incorporation of new data.

63. In the context of mutual funds, there may be fundamental limitations on the percentage of assets that must be invested in a particular capitalization range, limits on investment concentrations in a particular industry, etc.

ager may assume relative to a benchmark, or limit investments to "long only."[64]

If not mandated by a client or produced in disclosures to potential clients, guidelines may or may not be hardwired into a portfolio. For example, a strategy may focus on investments in a defined capitalization range (e.g., mid-cap) or a manager may have hard and soft rules limiting concentrations of an individual stock (e.g., two percent of a portfolio), the number of stocks (e.g., no more than fifty positions), or sector concentrations (e.g., plus or minus five percent of benchmark concentrations). However, the portfolio manager may be allowed to use his or her judgment to make exceptions to these general guidelines.[65]

As the foregoing discussion illustrates, despite its seemingly passionless image, the development of models and the application of model signals in the management of advised assets can be a complex process that involves numerous subjective decisions. Section I.B describes the model development process, safeguards designed to prevent errors, and the uncertainty of model performance.

B. *Model Governance, Types of Model Errors, and Controls*

All or a portion of quantitative investment models used by a manager may be developed internally by an adviser, licensed from third-party vendors that specialize in the research and development of models, or created by independent professionals that are retained by the manager to assist in constructing the model. Within larger asset managers, it is not uncom-

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64. It is important to note that managers may use derivatives to acquire exposure to sectors or factors, or to hedge the risk of overexposure to sectors or factors.

65. If limits are "soft," a manager may balance risk and return within a strategy by retaining discretion to maintain an existing position or exposure that remains attractive, but due to price appreciation is greater than a defined (e.g., 2%) percentage of the portfolio or exceeds the capitalization range of the strategy. Positions also may be allowed to drift between rebalancing periods. However, any deviation from benchmark parameters (including not owning significant positions in a benchmark index) exposes the portfolio to tracking risk. Institutional managers frequently are selected for specific assignments in a larger portfolio and may be replaced if they stray from their style. In some cases, the client mandate may include a specific tracking error limit that is calculated based on the standard deviation of the difference in the portfolio and the benchmark (e.g., 1.5%–3%).

mon to find separate academically-oriented research centers, or groups, that employ Ph.Ds. to develop and refine their models.[66] Some firms, in fact, are reported to employ over 100 Ph.Ds. These groups may be developed organically or acquired as teams coming from other managers. Moreover, like research teams at traditional managers, multiple groups may exist in some larger firms, with each group specializing in a different asset class, strategy, or region of the world. However, because of the scalability noted earlier, quantitative managers also may be entrepreneurial organizations with less than a handful of academics and technology experts.

From an organizational perspective, research centers at larger firms also may be internal to a manager or located within affiliates that are separately organized and that license their models to other affiliates.[67] The research and modeling conducted by these groups may be independent,[68] or may be directed by portfolio managers, including those applying a traditional approach to investing.[69] Depending on the organi-

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66. Most model developers have at least a master's degree and frequently a PhD in a subject, such as economics, mathematics, finance, statistics, financial engineering, or computational finance.

67. These groups also may hold the proprietary data and any patents on the manager's models. In some cases, the research affiliates may view themselves as technology companies who also operate in the investment management industry.

68. In some cases, the groups are considered to be independent think tanks and may be analogized to "skunk works," a term derived from the defense industry that is now used commonly in technical fields, as well as business and engineering, to refer to a group within an organization that operates with a high level of autonomy, unhampered by bureaucracy, that is charged with working on advanced (or secret) research or projects. *See generally* WARREN G. BENNIS & PATRICIA WARD BIEDERMAN, ORGANIZING GENIUS: THE SECRETS OF CREATIVE COLLABORATION (Basic Books 2d ed. 1998) (1997) (describing the origins of skunk works and the purpose of these units).

69. Because of the extremely competitive nature of markets, if managers do not protect their successful investment models from theft or misuse, their investors may lose the benefit of any advantage the models offer. To protect the intellectual property of a manager, frequently only a limited number of individuals within the firm will have knowledge of every aspect of their models. In addition, managers may require employees to sign confidentiality agreements and take measures that include the use of firewalls to limit employees' access to information, including source code. These security measures also may be necessary to protect the integrity of the models or to create information barriers for regulatory purposes. Because of the proprietary na-

zational structure and culture of the manager, they may have greater or lesser degrees of autonomy and empowerment.

It also is not uncommon for a manager to rely on both internally developed models and third-party models. Third-party models may have varying degrees of sophistication and customization.[70] These models often are integrated with proprietary or third-party data bases and, among many other things, allow managers to employ multifactor screens, develop investment strategies, back-test their strategies and simulate returns in different environments, construct and monitor portfolios, optimize exposures and weightings, perform attribution analysis, and generate reports. In addition, as described earlier, they may be used by risk teams as an independent safeguard to test the output of internally developed models.

Whether models are developed internally or by third parties, because they are designed and implemented by humans, they are inherently prone to different types of errors. Many firms have formal model risk governance structures with detailed, documented protocols for model development changes and implementation.[71] Governance committees, for example,

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ture of their strategies, managers often are reluctant to share detailed information with regulators as a routine matter.

70. Some smaller firms without personnel that have the background to develop internal models may rely heavily on third-party models. Many third-party models have relatively simple user interfaces and can be employed by managers with varying degrees of sophistication and knowledge about the math supporting the models.

71. Oversight of models broadly includes the application of controls over model development and ongoing validation. Various bank regulators have issued guidance on model governance in recent years with respect to a variety of models relied on by banks and other financial institutions in the context of "safety and soundness" requirements. *See, e.g.*, FDIC, DIRECTOR, JOINT AGENCY POLICY STATEMENT ON INTEREST RATE RISK, FIL-52-96, 1996 WL 399803 (June 26, 1996); OFFICE OF THE COMPTROLLER OF THE CURRENCY, BD. OF GOVERNORS OF THE FED. RESERVE SYS., OCC BULL. NO. 2011-12, MODEL RISK MANAGEMENT (2011) [hereinafter OCC Bulletin]; OFFICE OF THE COMPTROLLER OF THE CURRENCY, BD. OF GOVERNORS OF THE FED. RESERVE SYS., OCC BULL NO. 2000-16, ADVISORY ON INTEREST RATE RISK MANAGEMENT (2010); FED. HOUSING FIN. AGENCY, MODEL RISK MANAGEMENT GUIDANCE, AB 2013-7 (2013). *See also* Model Risk Working Party, Inst. and Fac. Actuaries, Presentation at the Sessional Meeting of the Insitute and Faculty of Actuaries: *Model Risk: Daring to Open up the Black Box* (Mar. 23, 2015), https://www.actuaries.org.uk/documents/sessional-paper-model-risk-daring-open-black-box (providing an excellent overview of model risk governance). Similar guidance is being proposed by the CFTC and in the brokerage industry

may, among other things, review and approve material model changes and developments, review model validation reports, monitor compliance of model development with modeling protocols, escalate breaches appropriately, and approve the appropriateness of proposed action plans to rectify a problem. Managers also may have an internal audit function that is part of the model governance process.

As suggested above, because models are built by humans, they are prone to a variety of errors including misjudgments in model construction, bad data sources, slippage in implementation, and programming mistakes. Models are especially likely to have errors as they grow more complex.[72] The errors can arise in many in different contexts. Several of the broad categories of errors include model design errors, programming or coding errors, and data integrity errors—each of which may pose a different kind of risk. In addition, problems may occur with the technology and systems used by the models, including outages and the potential for viruses and malware, among many others. Even when models operate as intended, they may not be correctly calibrated or their signals or other results may be misapplied or misinterpreted if portfolio managers and others who rely on the models to make decisions are not skilled or appropriately trained. For these reasons, managers' investment processes are frequently designed to be robust or resilient to errors.

Following is a brief overview of how models are designed and the governance process intended to prevent or mitigate the effect of inevitable errors. The following Sections of this Article emphasize that model governance is not just focused on pre-implementation controls, but also the detection and remediation of errors that are discovered after a model is in "production."

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because of market structure concerns posed by high frequency trading. *See infra* note 264; *see also* FUTURES INDUSTRY ASSOCIATION, *Software Development and Change Management Recommendations* (Mar. 2012) https://secure.fia.org/downloads/software_change_management.pdf [hereinafter FIA Guidance].

72. *See generally* Eric Bonabeau, *Understanding and Managing Complexity Risk*, 48 MIT SLOAN MGMT. REV. 62, 62 (2007) (noting that "[v]ulnerabilities enter organizations and other human-designed systems as they grow more complex" and that "some systems are so complex that they defy a thorough understanding").

1. *Model Design Controls*

Design errors include mistakes in theory, math, logic, assumptions, and the failure to include variables; reliance on corrupt, stale, or missing data in the review process that can produce bias or inaccurate results; and flawed or imperfect validation or other test procedures. Prior to implementing a model, "back testing" is used to determine whether the model would have been successful in prior market environments. Simulations or stress tests may seek to estimate the success of a model or factors in hypothetical conditions that the model may encounter in the future.[73] One of the key pre-implementation controls over model design errors is whether the underpinnings are sound and the results produced by a model are consistent with the anticipated outcomes.[74] In larger managers, an independent team may validate the model or enhancement to verify that it produces portfolios that are consistent with the manager's investment approach.

2. *Programming Controls*

Financial theories are expressed as mathematical equations.[75] Once an algorithm has been researched and approved for integration into a model, a programmer uses code to write software in a programming language[76] that will encapsulate

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73. The validation of models and research itself is a highly sophisticated science.

74. *See generally* Susan Mangiero, *The Risks of Ignoring Model Risk*, *in* LITIGATION SERVICES HANDBOOK: THE ROLE OF THE FINANCIAL EXPERT (Roman L. Weil et al., eds., John Wiley & Sons, 3d ed. 2005).

75. For example, one element of a larger formula might incorporate a model for the scaled dispersion of earnings forecasts by analysts before and after earnings announcements expressed as:

$$change\ DISP_{j,t} = \frac{St.Dev_{[0,+30]}(F_{j,t})}{abs[Avg_{|0,+30|}(F_{j,t})]} - \frac{St.Dev_{[-60,-1]}(F_{j,t})}{abs[Avg_{|-60,-1|}(F_{j,t})]}$$

See, e.g., Alina Lerman, Joshua Livnat & Richard R. Mendenhall, *The High-Volume Return Premium and Post-Earnings Announcement Drift* (Working Paper, Apr. 2008), https://ssrn.com/abstract=1122463.

76. The coding used by programmers is called the "source code." To execute the program, the source code must be converted into "machine language" or "object code" that can be understood by a computer. However, source code is the only format readable by humans. Third-party software often is provided in machine language that cannot be read directly or modified.

changes by accessing relevant data and performing the desired computations. Programming of sophisticated software is universally regarded as a highly complex, subjective process that requires abstract reasoning. For this reason, quantitative programmers retained to perform this function often are very well educated and highly compensated.

a. "Wabi-Sabi"—There Is No Perfect Programming (or Model)

There are no uniform standards for coding financial software. The specific controls and approaches to program development, including the frequency of review, necessary documentation of coding, and flow and formation of modeling teams are the subject of high level debate.[77] *Wabi-Sabi* is a 700-year-old Japanese philosophy based on tenets of Buddhism that emphasizes appreciation of the beauty in imperfection and the notion that nothing is perfect, complete, or permanent. This philosophy has been used to describe the ongoing process of programming and model development using the "Agile" methodology—which is the methodology most commonly used in the financial services industry.[78] Specifically,

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It is estimated that there are hundreds or thousands of different types of coding languages in existence designed for different operating systems and purposes. Models that are developed over a period of time may have modules written in different languages, including non-standard languages. "C++" is a common language used in financial modeling. Below is an illustration of lines of source code from "C++":

```
return m_nSInitial * exp(m_nDrift*m_nCurrentTime
– .5* m_nSigma * m_nSigma*m_nCurrentTime
+ m_nSigma*m_nCurrentDiffusion)
);
```

77. Separate software programs often detect keystroke errors. Logic errors are harder to prevent, however. Nevertheless, developers focus on education and training, as well design specifications and some automated processes for testing. However, formal design specifications generally are believed to be impractical for larger programs.

78. "Agile" programming is considered the norm in many portions of the financial community because it is lightweight and "agile." The benefit of Agile programming methodology is that because it is based on evolutionary development and continuous improvement, it is faster to produce. In contrast, the other major methodology, the "Waterfall" methodology, has greater documentation and certainty, but is a slower sequential process with phases that include conception, initiation, analysis, design, construction, testing (verification), production (implementation), and maintenance.

like models themselves, no programming is believed to be perfect, permanent, or complete. Instead, there is continuous correction and improvement. In modern model development, the process of governing the evolution of model software is referred to as the "software development life cycle."

Producing error-free code has so far proven nearly impossible and software programming universally is regarded as an error prone process. Debugging software often is a highly skilled task and it is widely acknowledged that the nature of software development makes bug-free software unattainable. This is especially so in the case of complex models with numerous interactions among different programs where models have been developed over an extended period of time by multiple individuals using different coding languages.

b. Examples of Programming Errors

Programming errors often relate to logical decisions, planning, miscommunication, incorrect inputs, lack of technical expertise, or imperfect understanding of interactions with other parts of a model. They also may result from simple typographical, syntax, or scaling mistakes. These types of errors are often referred to as "bugs,[79] mistakes, flaws, defects, incidents, faults, exceptions, or imperfections," among many other terms. Even when the errors appear to be based on keystroke entries, they may nonetheless in many cases be due to flaws in the logic or analytical process applied by a programmer. One of the more popular illustrations of logic errors in software programs is found in the book, and movie by the same name, "2001: A Space Odyssey," in which HAL, the onboard computer of a spaceship, becomes homicidal due to conflicting programming objectives.[80]

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79. Some commenters suggest that the term "bugs" first was used by the inventor Thomas Edison, who referred to "bugs" in describing "little faults and difficulties" that must be worked through as part of the development process of an invention. *See, e.g.*, Letter from Thomas Edison to Tivadar Puskás (Nov. 13, 1878), *in* THOMAS PARKE HUGHES, AMERICAN GENESIS: A CENTURY OF INVENTION AND TECHNOLOGICAL ENTHUSIASM 1870–1970 at 75 (1989).

80. In the book and movie by the same name, HAL is unable to resolve a conflict between his general instruction, which is to relay information accurately, and specific instructions to withhold information about the true pur-

In the real world, heroic efforts by various governments to produce error free code, which may be cost prohibitive for commercial developers or advisers, also have not been entirely successful, leading to highly public disasters.[81] For example, NASA has devoted substantial resources in an attempt to produce virtually error-free code. Even with resources that may not available to non-government vendors, NASA nonetheless experienced well-publicized incidents in which devices used in space exploration (e.g., Mariner 1 and Mars Climate Orbiter) or for other purposes were destroyed or rendered inoperable due to latent software errors.[82]

Errors may be extremely difficult to detect if, as illustrated by the Mars Climate Orbiter disaster, they are latent and do not appear to interfere with the operation of a program.[83] The Mars Climate Orbiter, for example, was launched by NASA in 1999 with the objective of orbiting Mars and providing information about the climate and atmosphere of Mars.[84] A common scaling error (using metric units rather than Imperial units) in one part of the software prevented a NASA team from accurately guiding the spacecraft on its 416-million-mile journey to Mars.[85] Because of the error, the spacecraft missed

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pose of the mission from the humans on board. *See* ARTHUR C. CLARKE, 2001: A SPACE ODYSSEY (1968); 2001: A Space Odyssey (1968).

81. *See, e.g.*, *List of Software Bugs*, WIKIPEDIA, http://en.wikipedia.org/wiki/List_of software bugs (last updated Mar. 29, 2017).

82. Latent errors, for example, may not appear except in unusual circumstances, or in connection with model enhancements or revisions. In these instances, the symptoms of an error may not be apparent until highlighted by an external trigger.

83. In general, there are several primary types of programming errors that may affect quantitative models. These include: logic errors in which variables or conditions are not described correctly and the result does not follow the rules of logic; syntax errors in which a function is used incorrectly or a variable is misspelled, which results in the computer not being able to understand the program; and design errors in which a flaw in an algorithm or flow of processing causes an incorrect or incomplete result. Some errors (for example those that may cause a program not to operate) are easily detected, while others may be more difficult to detect and remedy.

84. *See Mars Climate Orbiter: Mission Overview*, NASA, https://mars.nasa.gov/msp98/orbiter/mission.html.

85. *See* Press Release, NASA, Mars Climate Orbiter Team Finds Likely Cause of Loss (Sept. 30, 1999), https://mars.nasa.gov/msp98 /news/mco990930.html; *see also* Mars Climate Orbiter, Mishap Investigation Board Phase I Report (Nov. 10, 1999), http://sunnyday.mit.edu/accidents / MCO_report.pdf.

its mark by only sixty miles and is presumed to have entered the atmosphere of Mars on the wrong trajectory and disintegrated. NASA indicated that the error, which affected the thrusters, was not detected for many months because the error contributed only a small part of a much larger number in guidance of the spacecraft.

Software used both for investment management and commercial purposes may have millions of lines of code and is considered to be virtually incapable of being fully field tested prior to implementation. Moreover, programming and other model development errors can be introduced at any point in the development or refinement of a model—even after models have been tested and placed into production (i.e., the model is being used). In addition, code that appears error-free at the time of origin may degrade over time due to many factors, including the implementation of changes and workarounds.

Because of the ubiquity of errors, third-party software vendors in every industry license products on an "as-is" basis since they are presumed to have errors. Vendors also routinely issue patches and updates to correct these errors and improve their software products.[86] Thus, consumers must regularly download new versions, or updates, of software on their computers and cell phones that are intended to repair errors discovered post-release. For instance, quality commercial software is reported by one source to average one defect in coding for every 1000 lines of code (referred to as "defect density"), with the defect density increasing with the number of lines of code in the model.[87]

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86. *See* RESEARCH TRIANGLE INSTITUTE, THE ECONOMIC IMPACTS OF INADEQUATE INFRASTRUCTURE FOR SOFTWARE TESTING, NIST PLANNING REPORT 02-3 (2002) (recognizing that all software defects cannot be removed and noting that "[s]oftware is error-ridden in part because of its growing complexity. The size of software products is no longer measured in thousands of lines of code, but in millions. Software developers already spend approximately 80 percent of development costs on identifying and correcting defects, and yet few products of any type other than software are shipped with such high levels of errors.").

87. These studies were initiated by the Coverity Scan service in conjunction with the Department of Homeland Security and have examined 450 million lines of code. The Report details specific types of errors that are considered "defects," which may be broader or narrower than the definition used by others. COVERITY SCAN: 2012 OPEN SOURCE REPORT (2012).

3. *Data Comprehensiveness and Integrity Controls*

Data is the lifeblood of quantitative managers, but may be another source of errors. The information available to asset managers and commercial users today is overwhelming. Quantitative investment models process enormous amounts of data from a variety of internal and external sources. Although some firms maintain large proprietary databases, a significant portion of the data relied on by managers in constructing and implementing models frequently is supplied by third-party vendors, including data aggregators or data brokers.

Some managers, for example, may attempt to harness a wide range of data from hundreds, or thousands, of varied sources. The data may include financial ratios and other information extracted from financial reports filed with the SEC, analysts' estimates revisions, price quotations, exchange rates, interest rates, and other statistical and market information, just to name a few. And, as discussed later, both managers and third-party vendors may attempt to quantify new sources of qualitative information for models that they believe will offer a competitive advantage, including big data.[88]

If data that a manager chooses to construct, validate (including back-testing and simulations), and implement in its model is flawed, corrupt, not sufficiently comprehensive, or too comprehensive, not converted correctly, or weighted improperly, it may affect model forecasts (i.e., "garbage in, garbage out").[89] Thus, managers typically have data integrity controls, including algorithms that scrub, clean, cull, or harmonize data.

The importance placed on data is seen in the emergence of the title Chief Data Officer (CDO) or Data Governance Director, and Data Scientist within both quantitative asset managers and other firms relying on quantitative research techniques, and among the merchants and platforms providing

88. Data scrubbing is part of larger data integrity controls that also insures that data is stored correctly and not corrupted. In addition, managers may use robust statistics in their models, which is designed to neutralize the effect of data that is considered to be an outlier.

89. In many cases, data, while potentially helpful, is not easily available or too costly to produce or purchase. Some data, while available, may produce noise that distorts forecasts. Thus, managers use discretion in determining which data to gather for their models in light of statistical sampling methodology, their resources, and their investment philosophy.

data for dollars. CDOs are part of the ownership chain of models. Their responsibilities vary, but may include developing a data governance program that assures data integrity and uniformity, database management, vendor selection and management, integration of data across platforms, and storage.[90] Individuals within business lines responsible for data are sometimes referred to as "data stewards" or "data curators" and sit on data governance committees headed by the CDO.[91]

4. *Post-Implementation Controls, Monitoring, and Model Enhancement*

There are numerous limitations inherent in the use of models, including both the possibility of different types of errors as well as decay in the strength of signals and changes in market environments that can affect historical paradigms. Because of these limitations, the post-implementation change management process includes model enhancements (and interventions) and the resolution of errors, once discovered.[92] Thus, overlaying individual controls with respect to model development, programming and data integrity, there is a continual monitoring of model output and portfolio performance that is intended to mitigate the effect of errors and the decline of model signals. As mentioned earlier, depending on the size of the manager, monitoring may occur both at the portfolio level by an individual portfolio manager or team, and as part of an oversight function by a risk group.[93]

Investment professionals responsible for oversight of quantitative models typically are well-educated, experienced,

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90. Although not discussed here, the recordkeeping requirements in the Investment Advisers Act and Rule 204-2 do not contemplate the enormous variety of information produced or relied on by quantitative managers. 15 U.S.C. § 80b–4 (2011); 17 CFR 275.204-2 (2011).

91. *See generally* Chris Kentoris, *Asset Managers Attack Data Silos with Governance*, FINOPS REPORT (July 23, 2016), http://finops.co/operations /asset-managers-attack-data-silos-with-governance/.

92. *See generally* FIA Guidance, *supra* note 71 (discussing change control procedures).

93. In addition to ongoing monitoring of results following implementation, models may be independently evaluated—or validated—periodically (including daily) through benchmarking and other means. In some cases, model results may be replicated in separate, non-production platforms or using third-party software. This testing may be performed by other internal team members, risk management, internal auditors, or outside consultants.

and understand the assumptions inherent in the strategies they employ, as well as the expected risks associated with exposures presented in client portfolios. As discussed previously, portfolio managers regularly review model output, both in connection with stock selection and in monitoring portfolios on an ongoing basis—appraising the evolving risk characteristics of a portfolio, including overweight and underweight holdings, significant alpha changes, factor exposures, performance, and correlations to benchmarks. By monitoring the composition of portfolios and performing various cross checks, portfolio managers, investment committees,[94] or risk officers are part of a feedback loop that provides insight into whether or not portfolios are composed of the types of investments and exposures that are anticipated and which express the manager's core beliefs.[95] The manager can then make a decision about whether or not to take action with respect to a portfolio, or to intervene by addressing errors or making enhancements to its models.

Ongoing research and model enhancement also is a routine part of the model development and investment process at most managers and is frequently part of the model governance process. Managers regularly decompose performance to identify the contribution of factors. For example, the insight provided by predictive or forecasting models ("alpha streams") can degrade or decay over time as other managers incorporate the same research tools causing them to attempt to establish or liquidate positions in the same stocks, driving prices up or

94. An investment committee at a quantitative manager functions differently than at a traditional manager, since it is less likely to be focused on discussing and resolving opinions on individual positions and industry allocations that may affect the day-to-day investment decisions of a portfolio manager. The investment committee at a quantitative manager may direct research, approve modifications or enhancements, and address errors. In some cases, the investment committee also may assure that a new model does not "cannibalize' opportunities identified by another model.

95. A key control for long-term investors is the predicted beta tracking error for a strategy versus its benchmark. As part of the ongoing monitoring process, and to safeguard against errors affecting model output, managers also employ variance controls that alert them to material variances in the characteristics of a portfolio and returns relative to its benchmark that may signal the need to conduct further review of their models to discover potential problems.

down (e.g., there is too much money in a strategy).[96] Ongoing research related to model development may focus on employing sources of data, identifying unique factors or market themes and relationships that can be exploited; may analyze factors in an existing model that have contributed to over- or under-performance during a period; may seek new understandings based on research or changing market environments; or may explore new analytical methods.[97] A significant amount of research in recent years has been focused on new data sources and a variety of "machine learning" techniques in which models are able to detect hidden patterns from which they make predictions.

a. New Insights from Big Data

Modern asset managers drink from the fire hydrant as they are continually exposed to new sources of data that might provide an analytical edge. Managers often are deluged by vendors that seek to provide new data that may be insightful. A new wave of quantitative research, used in many different industries, is based on machine learning, artificial intelligence, and other methodologies that seek to gain insights by exploiting big data. Quantitative analytical techniques may be used by a broad array of organizations. However, big data is regarded as a transformative development that has provided fresh opportunities for asset managers.

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96. A wealth of studies have debated whether or not active managers possess the skill to outperform the market as a whole. *See, e.g*, Eugene F. Fama, *Random Walks In Stock Market Prices,* 21 FIN. ANALYSTS J. 55 (1965) (proposing the "Efficient Market Hypothesis"). *But see, e.g.*, J. Doyne Farmer & Andrew W. Lo, *Frontiers of Finance: Evolution and Efficient Markets*, 96 PROC. NATL. ACAD. SCI. USA 9991, 9992 (expanding on the Efficient Markets Hypothesis and noting that "[p]rofitable strategies accumulate capital with the passage of time, and unprofitable strategies lose money and may eventually disappear. A financial market can thus be viewed as a co-evolving ecology of trading strategies. The strategy is analogous to a biological species. . . . The creation of new strategies may alter the profitability of pre-existing strategies, in some cases replacing them or driving them extinct.")

97. "Econophysics" is a term used to describe the application of tools used in other sciences, such as fluid dynamics and quantum mechanics, to financial models.

Frequently, the term "big data" is used to refer to large amounts of structured and non-structured information,[98] and includes data gathered from public social media websites such as Facebook and Twitter,[99] or search engines such as Google and Yahoo. Insights also may come from crowd sourcing,[100] anonymized or aggregate financial information obtained from service providers, tracking cell phone activity (including locations), and other "soft information" gathered from scraping or harvesting public information on websites.[101] The insights, however, must be teased out of the voluminous data using machine learning, artificial intelligence, and sophisticated statistics and may require a thorough understanding of the relevant business.

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98. A "database" is an arrangement of information. Relational databases contain "structured" information that is organized and easily searchable, such as a spreadsheet which has numerical information. "Non-structured" information includes qualitative information that does not easily fit in relational databases.

99. For example, a "sense and response" algorithm may be part of a larger "smart" platform that predicts buy or sell sentiment several days in advance based on "happy" or "unhappy" tweets. Programs assign numeric values to the tweets which are then incorporated into models. Recently, insights based on tweets, reflecting market sentiment about a stock, have been made available on at least one of the major providers of securities trading terminals. *See Trending on Twitter: Social Sentiment Analytics*, BLOOMBERG (Feb. 20, 2014), https://www.bloomberg.com/company/announcements/trending-on-twitter-social-sentiment-analytics/

100. "Crowdsourcing" seeks to gather the wisdom of the crowd. Some third parties have developed datasets that use open platforms which invite, and score, earnings estimates and other information from thousands of buy side (research employees of asset managers) and sell side (employees of brokers) analysts and traders, as well as portfolio managers at hedge funds and traditional asset management firms, third-party research providers, etc. The data is provided with varying degrees of participant anonymity. Firms also may employ quantitative research techniques to rapidly analyze and assign a numerical value to thousands of traditional sell-side research reports as they become available.

101. Web scraping, web harvesting, or web data extraction also can be a source of "outsider trading" if the information gained from the website is not available to the public. The SEC has initiated enforcement actions against hackers that used deceptive means to obtain non-public information on websites for trading purposes. *See generally* John Reed Stark, *The SEC's "Outsider Trading" Dragnet,* CYBERSEC. DOCKET (June 25, 2015, 11:06 AM); *see also, e.g.*, Press Release, SEC, SEC Charges 32 Defendants in Scheme to Trade on Hacked News Releases, Rel. No. 2015-163 (Aug. 11, 2015).

The information derived from big data may be of interest to companies selling products as well as to potential investors in those companies and regulators like the SEC.[102] For example, both operating companies and investors can use big data to gain deeper insights into industry trends and customer behavior. In the case of merchants, big data may allow them to make more accurate decisions relating to marketing, advertising, merchandising, operations, and customer retention. Information extracted from big data by asset managers can be used to forecast earnings,[103] short-term trading trends, or other market-moving announcements.[104] In fact, the ability of

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102. *See, e.g.*, A Vision for Data at the SEC, Keynote address by SEC Commissioner Kara M. Stein to Big Data in Finance Conference (Oct. 28, 2016); Has Big Data Made Us Lazy? Speech by Scott W. Bauguess, Deputy Director and Deputy Chief Economist, DERA, at the Midwest Region Meeting—American Accounting Association (AAA), Chicago Illinois (October 21, 2016).

103. Quantitative advisers also may gain insight from a wealth of data relating to investing trends, such anonymized or aggregated flow information obtained from custodians, asset servicers, and third-party administrators. This information may be used for investment purposes, product marketing, or to define risk profiles for retail investors.

104. Although beyond the scope of this Article, some sources of information may suggest insider trading concerns. However, information obtained from the internet or data from vendors that is anonymized or aggregated may be basically the same type of "channel checking"—including supply chain research, or looking at the "sale racks" or satellite photos of parking lots (in the case of retail stores)—that has become prevalent in recent years, but generally should not present insider trading concerns. *See generally* Marron C. Doherty, *Regulating Channel Checks: Clarifying the Legality of Supply Chain Research*, 8 BROOK. J. CORP. FIN. & COM. L. 470 (2014) (discussing supply-chain research, channel checks, and expert networks, and the SEC's insider trading concerns). *See also* Press Release, SEC, SEC Charges Hedge Fund Managers and Traders in $30 Million Expert Network Insider Trading Scheme, Rel. No. 2011-40 (Feb. 8, 2011) ("[I]t is legal to obtain expert advice and analysis through expert networking arrangements . . . ."); Michael W. Mayhew, http://www. businessinsider.com/author/michael-w-mayhew*Feds Agree: Expert Networks Are Okay*, BUSINESS INSIDER (Feb. 28, 2011, 5:22 PM) http://www. businessinsider.com/feds-agree-expert-networks-okay-2011-2 (quoting senior SEC officials and a U.S. attorney saying that "expert networks" do not inherently raise insider trading concerns); Bradley J. Bondi & Steven D. Lofchie, *The Law of Insider Trading: Legal Theories, Common Defenses, and Best Practices for Ensuring Compliance*, 8 N.Y.U. J.L. & BUS. 151, 173–74 (2011) (discussing theories regarding whether information is in the public domain for insider trading purposes, and noting "[i]nformation can reach the public domain through a variety of traditional means, including corporate disclosures, press releases, media interviews, analyst and investor

advisers to interrogate large quantities of information permits advisers to forecast a variety of macroeconomic and company-specific events[105] before the information is published. This may challenge the notion that there is parity of information in the markets, except that— for a price— all investors may acquire and process similar data.[106]

b. Design Modifications Due to Abnormal Market Conditions

Any decision to intervene and adjust a model may be difficult. Models generally are probabilistic and based on historically rational expectations. The effectiveness of a manager's investment models may be highly dependent on external conditions that can evolve significantly either over time or rapidly in ways that are not fully anticipated due to macroeconomic de-

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conference calls, analyst reports, and television programs. In addition, new forms of electronic communication, such as online message boards, blogs, chatrooms, social media (e.g., Twitter, Facebook, MySpace, and Friendster), professional networking websites (e.g., LinkedIn, Plaxo, and Chamber), and specialized websites focused on leaked information (e.g., WikiLeaks), can place information in the public domain.").

From a materiality perspective, big data and much of the other statistical information gathered and analyzed using quantitative research techniques may be viewed as "tiles in a mosaic" because they rely on fundamentally isolated bits of information that are not significant by themselves until their value is unlocked. Each manager with access to the same data may use it differently. As one commenter noted, "insights concealed in the data do not appear on their own. They have to be teased out by someone with the right statistical skills, business understanding, and instinct." Anders Kirkeby, *Big Data: What It Is and What It Might Mean to Investment Managers*, J. APPLIED I.T. INV. MGMT. (Feb. 2015), http://www.simcorp.com/en/insights/journal/big-data-what-it-is-and-what-it-might-mean-to-investment-managers.

105. It is important to note that the output is predictive, and it may or may not be correct.

106. The New York Attorney General has expressed concern about what he terms the "early" release of market-moving data, including analysts' estimates, to certain quantitative managers, a practice he refers to as "Insider Trading 2.0." *See* Press Release, SEC, SEC's FY 2014 Enforcement Actions Span Securities Industry and Include First-Ever Cases, Rel. No. 2014-230 (Oct. 16, 2014). While it is not clear that any securities law violations have been discovered by the New York Attorney General, in various settlements with industry participants, they have agreed to refrain from acting on information until it is made available through mainstream channels. *But see, e.g.*, Chiarella v. U.S., 445 U.S. 222, 233 (1980) ("[N]either the Congress nor the Commission (SEC) ever has adopted a parity-of-information rule").

velopments, such as unpredictable changes in market sentiment, unforeseen economic developments, interest rates, regulatory changes, and domestic or foreign political actions (e.g., "Brexit"—the United Kingdom's vote to leave the European Union),[107] demographic or social events, as well as the extent to which other managers employ the same factors in their own models. And, a manager's strategies generally may not perform as hoped for extended periods, either because the manager's strategy is out of style (e.g., the market is favoring growth versus value) or because the manager's strategy is designed to perform better in up-market rather than down-market environments. In addition, while managers often perform scenario analysis or stress test their models, during a period of abnormal market conditions (or those in which the market is acting irrationally from the perspective of the probability-based model) models may not work in the same fashion as under normal conditions.[108]

Even during more normal market conditions, not all of the factors emphasized in a model may provide any predictive ability over a particular period.[109] Moreover, the significance of individual factors may change over a relatively short time frame. A factor affected by an error may or may not have contributed to relative performance as intended or, in some cases,

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107. Managers may attempt to quantify even these different types of political risk.

108. Because quantitative managers are often anchored to probabilities based on historical data, they may not be as nimble as traditional managers in responding to current market conditions. Traditional managers are believed to generally be better at adapting to unanticipated changes in market conditions due, in part, to the fact that some data resulting from market changes will appear in the research supporting quantitative models only at a later time. In this regard, some have analogized quantitative strategies, in particular, to driving down the road while looking in the rearview mirror.

109. Active investment management is based on the notion that there is a fair price that can be discovered, and that managers can take advantage of mispricings. Stock prices reflect, on a relative basis, the markets' consensus about a stock's potential for appreciation (e.g., undervalued or overvalued) evidenced through the forces of supply and demand. If the opinion of other investors in the market does not attribute value to those specific factors emphasized by a manager's model over a particular period of time (e.g., the market was valuing earnings improvements more than price to earnings ratios), ignores the factors, or views the factors negatively, then the factors employed in the model may have a neutral or negative effect on portfolio performance.

may affect performance in a manner that is not obvious. The uncertainty surrounding model results also may mask the presence of errors in model design, data, or programming. Therefore, any decision to intervene and change aspects of a model that appear not to be working may be difficult because of uncertainty over whether underperformance represents a temporary period of irrational behavior, a mistake in the design of the model, corrupt data, a latent flaw in programming, a paradigm shift, or something else.[110]

Under abnormal market conditions, in particular, decisions to modify a strategy become more complex. For example, conditions that are believed to occur only rarely may be based on the manager's statistical calculations (e.g., two percent probability), which assume a normal distribution. However, the return distribution on which a strategy is based may not turn out to be normal, and so-called tail risk (i.e., "fat tails"), or significant unpredicted events (known as "black swan events")[111] that result in negative outcomes may present difficult choices for the manager.[112] During extreme conditions, managers must consider whether the investment envi-

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110. John Maynard Keynes, the influential British economist, is famously quoted as stating: "[t]he market can stay irrational longer than you can stay solvent." And also, "[t]here is nothing so disastrous as a rational investment policy in an irrational world."

111. NASSIM NICHOLAS TALEB, THE BLACK SWAN: THE IMPACT OF THE HIGHLY IMPROBABLE 400 (1st ed. Apr. 2007). According to the author, black swan theory addresses unexpected events of large magnitude and consequence. These events are considered extreme outliers. "Tail risk" in a model is the based on a normal statistical distribution (i.e., a symmetrical bell curve with certain mathematical properties) and underpins many financial theories, like modern portfolio theory. It is the risk that an abnormal event will occur. In a normal distribution, 99.7% of occurrences will fall within three standard deviations of the mean. However, the risk that a black swan event will occur in the financial markets is not believed to be as rare as predicted using statistical models (called a "fat tail risk"). *See, e.g.*, Trevir Nath, *Fat Tail Risk: What It Means and Why You Should Be Aware of It*, NASDAQ (Nov. 02, 2015), http://www.nasdaq.com/article/fat-tail-risk-what-it-means-and-why-you-should-be-aware-of-it-cm537614#ixzz4gEVNt65g; *see also* Mohammed Riad & Kevin Timothy Swanson, Advisers Act Release No. 4420A, 2016 WL 3627183 (July 7, 2016) [hereinafter Riad Opinion] (2016 SEC opinion expressing the SEC's view regarding the frequency of what might otherwise be considered black swan events in the securities markets.).

112. The challenge faced by managers is no different than the risk that many consumers make when they plan winter vacations. They may look at the statistical average temperatures for an area during that time of year, but

ronment will revert to the norm, or whether a paradigm has changed in a significant manner that is not included in the historical data and research that produced the model (i.e., there is a new normal). For example, the odds of a 100-year storm occurring may have changed significantly as a result of global climate change. As one commenter observed ". . . what appears to be a model breakdown may, in reality, be nothing more than the inevitable fat-tailed behavior of model errors."[113] In this environment, some managers may use discretion to apply hard or soft investment guidelines and intervene and make adjustments if their models are driving portfolios toward significant over- or under-weight factor exposures relative to their benchmarks.

Two illustrations of the challenge faced by advisers during abnormal market conditions are shown in the Global Financial Crisis of 2007–2009, and the frequently cited collapse of Long-Term Capital Management (LTCM) in the late 1990s.

i. Global Financial Crisis of 2007–2009

During the Global Financial Crisis of 2007-2009 the investment strategies of both traditional managers and quantitative managers did not perform as predicted when factors that had been historically uncorrelated were affected by the same common factors. This period has been described "as one in which rare and unpredictable events . . . challenge conventional ideas about portfolio construction."[114] During this period, managers and their clients watched in horror as the S&P 500 index plunged dramatically before beginning a slow recovery. Government intervention was common and traditional correlations between investments that drove risk budgets and portfolio optimization models became unreliable. For example, international emerging markets and other asset classes, which historically had been identified as sources of diversification in the overall exposure of a portfolio, turned out to be highly

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they may still run the risk of unseasonably cold weather, wet weather, hurricanes, or even 100-year storms.

113. Fabozzi, Focardi & Jones, *supra* note 15, at 17; *see also* SEC Riad Opinion, *supra* note 111.

114. Abdullah Z. Sheikh & Hongtao Qiao, *Non-Normality of Market Returns: A Framework for Asset Allocation Decision Making*, 12 J. ALT. INVS. 8, 8 (2010).

correlated during this period (i.e., "crisis correlation").[115] Many alternative strategies marketed as defensive, or as offering stable returns in volatile markets, did not meet expectations.

ii. Long-Term Capital Management

A second notable illustration occurred in 1998 when LTCM (a quantitative manager) made headlines after losing $4.6 billion dollars of investor assets in less than four months.[116] The firm (whose principals included a host of well-credentialed Wall Street veterans, the former Vice Chair of the Federal Reserve Board, and current and former academics—including two Nobel Laureates in economics) developed and relied on highly sophisticated models to engage in derivative transactions designed to profit from the convergence of prices in various fixed income investments that had historically been highly correlated, but which LTCM perceived to be temporarily mispriced. The strategy involved tremendous leverage and, at one point, open positions held by LTCM were rumored to exceed one trillion dollars.[117]

The LTCM strategy was alleged to have failed when market prices did not converge, as the firm's models predicted, due to an event that they did not foresee (i.e., the Russian bond default) except as a random and extremely unlikely event. It was unclear, however, whether the losses resulting from LTCM's strategy were attributable to a design flaw, a misunderstanding of the risks inherent in their model, or a true black swan event. Nevertheless, LTCM often is cited as an ex-

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115. Managers relying on models may be more subject to crisis correlation and other crowding actions if a number of other firms are using similar models and decide to sell the same securities at the same time. The so-called "quant crunch" of 2007, for example, was attributed to too many quantitative managers using leverage and relying on models that emphasized the same factors. The staff of the Financial Stability Oversight Council (FSOC) is reported to have suggested that asset managers may rely too heavily on the same third-party risk models, with the result that flaws in those models could result in industry-wide problems. *See, e.g.*, Sarah N. Lynch, *Exclusive: Regulators Scrutinize Financial Risk-Modeling Firms*, REUTERS (May 14, 2014, 1:09 AM), http://www.reuters.com/article/us-financial-regulations-riskmodeling-idUSBREA4D04020140514.

116. *See generally* ROGER LOWENSTEIN, WHEN GENIUS FAILED, THE RISE AND FALL OF LONG-TERM CAPITAL MANAGEMENT (2000).

117. *Id.*

ample in which quantitative models designed by brilliant minds were not able to predict the future.[118]

The two illustrations show that strategies may not perform as anticipated—even if designed by brilliant individuals and implemented to perfection. They also reveal the challenge that advisers face in determining whether or not to intervene when their strategies are not performing as predicted during a particular period in time, and the impossibility of predicting the future.[119] Part II provides a general overview of both fiduciary and regulatory standards that apply to managers who use quantitative models. As Part II reveals, while managers may disappoint investors, they generally are not legally liable to investors simply because their strategy has imperfections of various kinds, or results in losses or underperformance.

II.
General Legal Standards Applicable to Quantitative Managers and Relevant SEC Precedent

Understanding the legal standards broadly applicable to managers is important. However, the laws and legal precedent were developed in an earlier era of the investment industry and in some cases may be difficult to apply to modern investment managers. The following section reviews the general legal standards applicable to investment advisers, and relevant SEC precedent relating to quantitative managers in particular.

A. *Fiduciary and Other Standards of Care*

Investment advisers are fiduciaries that have a duty of loyalty and care. The fiduciary law applied to investment advisers, including quantitative managers, has evolved from common law concepts and principles relating to trusts, negligence, tort, contract, and agency, among others. Separate standards are based on specific laws relating to investments by public and

118. Ultimately, the possibility of systemic risks resulting from the collapse of LTCM led to intervention by the Federal Reserve Bank of New York, which facilitated a recapitalization of LTCM by a consortium of large investment banks. *See, e.g.*, Lowenstein, *supra* note 116.

119. A strategy that is designed to be defensive and to account for the possibility of all negative market movements generally will sacrifice returns during favorable market conditions.

private pension plans, on disclosure concepts that have evolved under the Advisers Act and elsewhere.

Normally, an adviser will not be liable to investors so long as its conduct is not negligent or reckless. Heightened standards of care and additional disclosure obligations may be necessary based on the manner in which an adviser represents itself. For example, under prudent-expert standards, including those set forth in ERISA[120] and those that apply in many cases to advisers that manage assets for public entities, a manager that holds itself out as possessing special skills may be compared against other managers with similar skills—which may be other traditional or quantitative managers.[121] Elements that often may be considered by courts in determining whether or not a manager has met its standard of care are: the capabilities of the manager, the presence of a documented investment process, a research process that provides a reasonable basis for any recommendations, and regular monitoring of portfolios.[122]

The failure by an investment adviser, whether traditional or quantitative, to achieve a client's investment objectives does not, by itself, violate the law or constitute a breach of fiduciary duty. Investment management is a forward-looking pursuit. Ample legal precedent underscores the notion that fiduciaries are not expected to have a crystal ball to predict the future and that a fiduciary that exercises reasonable, but not perfect, care is not liable based on mistakes in judgment made in good

120. The fiduciary duties under ERISA are considered among the highest standards. *See, e.g.*, Donovan v. Bierworth, 680 F.2d 263, 271 (2d Cir.), *cert. denied*, 459 U.S. 1069 (1982).

121. ERISA fiduciaries are required to adhere to the ERISA prudent-man or prudent-person standard of care. ERISA § 404(a)(1)(B), 29 U.S.C. § 1104(a), provides that "a fiduciary shall discharge his duties with respect to a plan . . . with the care, skill, prudence, and diligence under the circumstances then prevailing that a prudent man acting in a like capacity and familiar with such matters would use in the conduct of an enterprise of like character and with like aims . . . ."

122. The Uniform Prudent Investor Act (UPIA), which has been adopted in most states and the District of Columbia, allows fiduciaries to utilize modern portfolio theory to guide investment decisions and requires risk versus return analysis. *See generally* UPIA § 3; *see also* RESTATEMENT (THIRD) OF TRUSTS § 227 (AM. LAW INST. 1992). Under this standard, a fiduciary's performance is measured on the performance of the entire portfolio, rather than its individual investments.

faith, or the outcome of investment decisions.[123] In the context of ERISA, which contains one of the highest prudential standards, the 11th Circuit stated:

> The ultimate outcome of the investment is not the yardstick by which the prudence of the fiduciary is measured; the court must consider the conduct of the fiduciary not the success of the investment, and the court must evaluate the fiduciary's conduct at the time of the investment decision rather than from the vantage point of hindsight.[124]

1. *Investment Advisers Act of 1940*

a. Disclosure-Based Fiduciary Standard

Under the federal securities laws, Section 206 of the Advisers Act makes it unlawful for either a quantitative or traditional investment adviser (1) to employ any device, scheme, or artifice to defraud any client or prospective client, (2) to engage in any transaction, practice, or course of business which operates as a fraud or deceit upon any client or prospective client or (3) to engage in any act, practice or course of business which is fraudulent, deceptive, or manipulative.[125]

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123. *See, e.g.*, Stark v. U.S. Trust Co. of New York, 445 F. Supp. 670, 678–79 ("A trustee's performance is not judged by success or failure . . . [and] a mere error in judgment will not [result in liability].") (citations omitted); *see also* RESTATEMENT (THIRD) OF TRUSTS § 90 cmt. b (AM. LAW INST. 2008) ("A trustee is not a guarantor of the trust's performance. . . . The question of whether a breach of trust occurred turns on the prudence and propriety of the trustee's conduct, not on the eventual results of investment decisions."); 3 Am. Jur. 2d *Agency* § 211 ("An agent who contracts to perform personal services does not undertake to render perfect service, and mere errors in judgment not due to want of care or diligence, or to fraud or unfair dealing, are not actionable. An agent is not an insurer against losses due to honest mistakes or errors of judgment."); *id.* at § 212 ("[E]ven an agent with purported special skills is not an insurer of his or her work and will not be responsible for a mere error in judgment where he or she exercised the due care and appropriate skill of the profession.") (citations omitted).

124. *See, e.g.*, GIW Industries Inc. v. Trevor, Stewart, Burton & Jacobsen, Inc., 895 F.2d 729 (11th Cir. 1990). In the context of ERISA, the prudence standard generally is based on whether or not the conduct of the fiduciary is consistent with the purposes of the plan. The doctrine of "procedural prudence" requires an analysis of the fiduciary's diligence in investigating investments, rather than results produced by the investment.

125. Investment Advisers Act of 1940 § 206, 15 U.S.C.A. § 80b-6 (West 2016).

The U.S. Supreme Court has held that Section 206 of the Advisers Act imposes on an investment adviser a fiduciary duty.[126] Addressing the traditional fiduciary duties of loyalty and care in the context of disclosure, the Court indicated that fiduciaries have an affirmative duty of "utmost good faith, and full and fair disclosure of all material facts," as well as an affirmative obligation "to employ reasonable care to avoid misleading" clients.[127] The Court also indicated that "full and frank disclosure" of conduct serves the purposes of the Advisers Act.[128]

With respect to the duty of loyalty, the Court stated that the Advisers Act is intended "to eliminate, or at least to expose, all conflicts of interest which might incline an investment adviser—consciously *or unconsciously*—to render advice which was not disinterested" and that investors "must . . . be permitted to evaluate overlapping motivations, through appropriate disclosure, in deciding whether an adviser is serving 'two masters' or only one, 'especially . . . if one of the masters happens to be economic self-interest.'"[129] The disclosure elements of fiduciary conduct under the Advisers Act, and the duty of care, also are the basis for precedent in SEC enforcement actions emphasizing that advisers must have a "reasonable basis" for their recommendations[130] or investment advice.[131] In addition to

126. SEC v. Capital Gains Research Bureau, Inc., 375 U.S. 180 (1963).

127. *Id.* at 194. As discussed later, an assessment of whether a matter is material depends on context: the "total mix" of information provided to the investor. *See infra* note 307 and accompanying text.

128. *Capital Gains*, 375 U.S. at 197. Under Advisers Act Rule 206(4)-8, 17 C.F.R. § 275.206(4)-8, it is unlawful for "any investment adviser to a pooled investment vehicle" to "[m]ake any untrue statement of a material fact or to omit to state a material fact necessary to make the statements made, in the light of the circumstances under which they were made, not misleading" or "[o]therwise engage in any act, practice, or course of business that is fraudulent, deceptive, or manipulative."

129. *Id.* at 196.

130. Although advisers generally have a "suitability" obligation, normally institutional managers (including mutual fund managers) are selected by investors to manage a "sleeve" of large portfolios and compete for mandates within the particular asset class (*e.g.*, large cap value). They generally are not asked to devise the overall investment strategy for the client. For this reason, in the mutual fund context, it is common for the fund to disclose that it is not a complete investment program.

131. *See, e.g.*, R. Plaze, *Regulation of Investment Advisers by the Securities and Exchange Commission*, (Stroock 2014); Alfred C. Rizzo, Investment Advisers

the general disclosure obligations under Section 206 of the Advisers Act, advisers are subject to specific disclosure requirements in the Form ADV,[132] may indirectly be subject to the Investment Company Act of 1940 form requirements for mutual funds (where relevant), and may be liable for materal omissions to the same extent as under Section 10(b) and Rule 10b-5[133] under the Securities Exchange Act of 1934.[134]

The entities subject to the Advisers Act are tremendously diverse and range from retail financial planners to sophisticated institutional assets managers and hedge fund managers. As noted earlier, the laws were written during a time when portfolio managers sought to assemble a portfolio of "good securities" for their clients. The laws and guidance applicable to advisers have not been amended to reflect the investment processes used by modern managers.

Act Release No. 897, 29 SEC Docket 782 (Jan. 11, 1984); Baskin Planning Consultants, Ltd., Investment Advisers Act Release No. 1297, 50 SEC Docket 661 (Dec. 19, 1991) (investment adviser did not "reasonably investigate" recommendations to clients); *see also* Winfield & Co., Inc., 44 SEC 810, 817-18 (1972) (investment adviser to an investment company did not make a reasonable investigation before purchasing securities); Christina Skousen, Exchange Act Release No. 45856, 77 SEC Docket 1429 (May 1, 2002) (investment adviser with no formal training prepared research reports and made performance projections without a reasonable basis); Gary L. Hamby. et al., Advisers Act Release No. 1668, 65 SEC Docket 1078 (Sept. 22, 1997). The SEC also has stated that the duty of care requires the adviser to "make reasonable investigation to determine that it is not basing its recommendations on materially inaccurate or incomplete information." *See*, Concept Release on the U.S. Proxy System, 75 Fed. Reg. 842982 (proposed July 14, 2010) (to be codified at 40 C.F.R. pts. 240, 270, 274, and 275).

132. Form ADV, for example, requires advisers to disclose conflicts of interest. *See generally* Amendments to Form ADV, 75 Fed. Reg. 49234 (Aug. 12, 2010) (to be codified at 17 C.F.R. pts. 275, 279).

133. 15 U.S.C. § 78j(b); 17 C.F.R. 240.10b-5. Rule 10b-5 prohibits "employ[ing] any device, scheme, or artifice to defraud;" "mak[ing] any untrue statement of a material fact or to omit to state a material fact necessary in order to make the statements made, in the light of the circumstances under which they were made, not misleading;" or "engag[ing] in any act, practice, or course of business which operates or would operate as a fraud or deceit upon any person." *Id.*

134. *See, e.g.*, Raymond J. Lucia Cos., Inc., Exchange Act Release No. 75837, 2015 WL 5172953, at *12 (Sept. 3, 2015) ("It is sufficient to note that [Advisers Act Sections 206(1), (2), and (4)] encompass the making of fraudulent misstatements of material fact and omissions of material fact necessary to make statements made not misleading."), pet. for review filed, No. 15-1345 (D.C. Cir. Oct. 5, 2015); *see also* Riad Opinion, *supra* note 111.

b. Other Relevant Requirements Under the Advisers Act

In addition to their broad disclosure obligations, Rule 206(4)-7 of the Advisors Act (the "Compliance Rule") requires investment advisers to adopt and implement written policies and procedures reasonably designed to prevent violation of the Act and its rules.[135] The SEC has stated that the compliance policies and procedures must be designed to "prevent violations from occurring, detect violations that have occurred, and correct promptly any violations that have occurred."[136] The SEC also has stated that the starting point for the preparation of policies and procedures is to first "identify conflicts and other compliance factors creating risk exposure for the firm and its clients in light of the firm's operations, and then design policies and procedures that address those risks."[137] A separate rule, Rule 204A-1 of the Advisers Act, requires advisers to have and enforce a written code of ethics.[138]

2. *Contractual Standards*

Advisers also have duties of a contractual nature to their clients under the terms of their advisory contracts with those clients. Investment advisory agreements typically grant the adviser discretionary authority to manage a client's account consistent with the investment objectives of the client and any investment limitations that the client may impose. These agreements also set forth the standard of care that applies to the reasonableness of the adviser's investment management activities.

At the institutional level, depending on the bargaining power of each side, advisory agreements may be the product of active negotiations between the adviser and the client—with

135. 17 C.F.R. § 275.206(4)-7 (2017). Section 204A of the Advisers Act also requires advisers to establish, maintain, and enforce written policies and procedures, consistent with the nature of their business, to prevent the misuse of material non-public information. 17 C.F.R. § 275.204A-1 (2012).

136. *See* Thomas P. Lemke & Gerald T. Lins, *Investment Adviser Examinations: Core Initial Request for Information*, 19A REG. FIN. PL. Appx. F6 (2008).

137. *Id.*

138. 17 C.F.R. § 275.204A-1 (2012). The Rule, which applies primarily to transactions by employees of the adviser, also requires an adviser to have "(1) [a] standard (or standards) of business conduct that you require of your supervised persons, which standard must reflect your fiduciary obligations and those of your supervised persons."

the client frequently producing the original draft of their standard investment management agreement. Agreements with public and private pension plans also may be subject to a specific fiduciary standard under local law. That standard can be simple negligence, which generally is defined as the failure to exercise the care that a reasonably prudent person would exercise a similar circumstance.[139] However, in other contexts, it is common for an adviser and its institutional clients to agree on a standard of care under the contract,[140] such as a provision that the manager will not be liable for any mistakes or errors in judgment in connection with its performance—or for losses arising out of any investment in connection with providing services—except in the case of willful misfeasance, bad faith, gross negligence or reckless disregard of the manager's obligations or duties.[141]

3. *Relevant SEC Precedent*

As discussed previously, the Advisers Act and the existing body of precedent derived from SEC enforcement actions under the Advisers Act was not developed in the context of the

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139. *See* 57A Am. Jur. 2d *Negligence* § 5. Although the appropriate standard of care is an issue of law, normally a reasonable person standard of care is applied. Industry conventions and protocols may be relevant in the analysis. *See id.* at § 164; *see also* Erlich v. First Nat'l Bank of Princeton, 208 N.J. Super. 264, 291, 505 A.2d 220, 234 (1984) ("Industry custom and practice are commonly looked to for illumination of the appropriate standard of care in a negligence case . . . ."). However, failure to observe industry conventions may not necessarily be negligent. *See* 57A Am. Jur. 2d *Negligence* § 165.

140. The Advisers Act prohibits so-called "hedge clauses" under which a client waives the adviser's compliance with the Act or any rule or regulation thereunder. *See* Heitman Capital Management, LLC, SEC No-Action Letter, 2007 WL 789073 (Apr. 12, 2007) (relating to hedge clauses in advisory agreements). Advisers may not use hedge clauses to disclaim responsibility for their actions if the disclaimer is inconsistent with applicable law. The SEC staff has stated that the inclusion of such a standard of care provision in an advisory contract would not constitute a per se violation of the antifraud provisions of Section 206 of the Advisers Act, indicating its view that whether such a provision would be a *hedge clause* that violates Section 206 will depend on all surrounding facts and circumstances, including the form and content of the particular clause, communications between the adviser and the client, and the sophistication of the client, among other factors. *See id.*

141. "Gross negligence" is generally defined under state law as the absence of slight diligence and is appreciably higher in magnitude than simple negligence.

variety of modern managers present today,[142] including quantitative managers. The SEC has brought enforcement actions against managers who represented that they had investment models that did not exist,[143] or that were based on advertising of hypothetical or flawed back-tested results.[144] However, the most relevant SEC precedent involving quantitative managers to date, and the first ever action against an adviser for errors in models used to manage investor assets,[145] are the two settled

142. *See, e.g.*, Barry P. Barbash & Jai Massari, *The Investment Advisers Act of 1940: Regulation by Accretion*, 39 RUTGERS L.J. 627 (2008) (noting that "[m]uch, if not most, of the existing body of enforcement-developed Section 206 rules [of the Advisers Act] was simply not developed with . . . [the current] variety of advisers in mind").

143. *See* Chariot Advisers LLC, Advisers Act Release No. 3872, 109 SEC Docket 1231 (July 3, 2014) (alleging that a manager sought board approval to form a new mutual fund and made representations to the fund's board of directors that it already had algorithms or computer models capable of engaging in the currency trading, which had not yet been developed); GMB Cap. Mgmt. LLC, Advisers Act Release No. 3399, 103 SEC Docket 1673 (Apr. 20, 2012) (alleging that an adviser represented to investors that it used quantitative pricing models to select hedge fund investments, when investment decisions actually were made without a model); *see also, e.g.*, Mkt. Timing Sys., Inc. et al., Advisers Act Release No. 2047, 78 SEC Docket 997 (Aug. 28, 2002); Schield Mgmt. Co. et al., Advisers Act Release No. 1872, 72 SEC Docket 1362 (May 31, 2000); LBS Cap. Mgmt., Inc., Advisers Act Release No. 1644, 65 SEC Docket 87 (July 18, 1997).

144. The SEC has brought enforcement actions against managers that have used flawed methodologies to produce back-tested and hypothetical performance results in their advertising. *See* F-Squared Investments, Inc., Advisers Act Release No. 3988, 110 SEC Docket 2953 (Dec. 22, 2014) (alleging that the adviser was aware that hypothetical results were based on flawed calculations, but used them in marketing materials anyway and also failed to disclose that performance results reflected back testing, and not actual results); *see also* Press Release, SEC, Investment Advisers Paying Penalties for Advertising False Performance Claims, Release No. 2016-167 (Aug. 25, 2016) (announcing thirteen SEC enforcement actions against firms who licensed the index from *F-Squared Investments, Inc.*, but did not independently substantiate its performance claims); Raymond J. Lucia Cos. et al, Exchange Act Release No. 495, 106 SEC Docket 3613 (July 8, 2013).

145. The Orders were strangely foreshadowed by an enforcement report from the SEC a year earlier also involving a model error, but in the context of a regulatory violation by a credit rating agency, and not a model used as an investment decision support tool. In this "model error" action, a rating agency allegedly learned of a coding error that caused its published ratings to be inaccurate and then attempted to hide the error, despite the fact that the market may have continued to rely on the inaccurate rating. An analyst at the rating agency discovered the error after comparing the rating agency's

enforcement actions in 2011 against Dr. Rosenberg and the firm that he co-founded.[146] The two separate Orders, the Firm Order[147] and the Rosenberg Order,[148] are important because the alleged facts and conclusions set forth in the Orders may lead to misconceptions about models and the investment management process, that in the future may result in a flawed legal analysis of model errors.[149]

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model results with that of an investment bank. In the SEC's report of the investigation, which was not an enforcement action, the SEC indicated—among other things—that once discovered the ratings were not changed, and the coding error may not have been disclosed because members of the agency's rating committee were concerned about possible reputational damage.

A year after the coding error was discovered, the rating committee voted to change the ratings, but did not disclose the fact that the earlier ratings were inaccurate due to the coding error. Several months later, the coding error was publicly revealed by the *Financial Times*, which then led the rating agency to conduct an internal investigation resulting in the termination of several senior employees on the rating committee. The SEC made cautionary statements, intended for others, highlighting that it felt the conduct was deceptive, that the rating agency did not follow its own controls, and that the agency did not take reasonable steps to assure that statements filed with the SEC were accurate, but the SEC stated that it determined not to take enforcement action because the activities occurred in Europe, rather than the United States. *See* Moody's Investors Service, Inc., Exchange Act Release No. 62802, 99 SEC Docket 765 (Aug. 31, 2010) [hereinafter Moody's 21(a) Report]; *see also* DBRS, Inc., Exchange Act Release No. 76261, 2015 WL 6447442 (Oct. 26, 2015) (a rating agency was alleged to have misrepresented that it used a quantitative process to monitor its outstanding ratings on securities each month).

146. In 2015 and early 2016 the SEC also announced insider trading enforcement actions involving big data and quantitative research techniques. Bonan Huang et al., Litigation Release No. 23179, 110 SEC Docket 3953 (Jan. 22, 2015) [hereinafter Huang Release] (the SEC charged two employees of a credit card company with insider trading. The employees are alleged to have used quantitative research techniques to query anonymized information about credit card purchases that they used to forecast company earnings and make investment decisions); *see also*http://www.sec.gov/ litigation/ litreleases/2015/lr23438.htm Bonan Huang et al., Litig. Release No. 23438, 2015 WL 9311910 (Dec. 23, 2015); Bonan Huang et al., Litig. Release No. 23445 (Jan. 14, 2016).

147. Firm Order, *supra* note 5.

148. Rosenberg Order, *supra* note 6.

149. The SEC staff also has issued guidance on issues associated with roboadvisers. While most of the guidance relates to models that address investor suitability, other portions address models more generally. *See* Guidance Update: Robo-Advisers 2017-02, SEC (Feb. 23, 2017), https://www.sec.gov /in-

a. The AXA Rosenberg Orders

The Orders involved the Firm, a parent company[150] of two registered investment advisers, which included an asset manager ("Asset Manager" or "ARIM") and a separately organized research group ("California Research Group" or "BRRC") that developed models which it licensed to the asset manager (together these are referred to as the "Firm"); and Dr. Rosenberg.[151] The Firm was an institutional manager known for its long-term, value-oriented approach to investing. Portfolio managers of the Asset Manager used models developed and licensed by the California Research Group (the "Firm Model") to assist in making investment decisions for individual client portfolios.[152]

In the Firm Order, the SEC explained that the Firm Model contained three principal components. These included an Alpha Model that searched for mispriced stocks with appropriate earnings and value characteristics; a Risk Model that examined specific stock risk and common factor risk; and an Optimizer designed to balance insights provided by the other two components, control risks, and then recommend an optimal portfolio based on the client's benchmark.[153] In 2007, the Firm made revisions to the Firm Model. According to the Firm Order, the revisions were implemented following research, back-testing, and simulations designed to assure that the Firm Model worked as intended following the revisions.[154]

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vestment/im-guidance-2017-02.pdf [hereinafter Robo-Adviser Guidance]; *see also* Investor Bulletin: Robo-Advisers, SEC (Feb. 23, 2017), https://www.investor.gov/additional-resources/news-alerts/alertsbulletins/investor-bulletin-robo-advisers.

150. The Firm was a subsidiary of one of the largest global financial institutions that had acquired the business co-founded by Dr. Rosenberg. Firm Order, *supra* note 5, at 2.

151. *Id.*

152. *Id.*

153. *Id.* at 3.

154. The Firm Order, *supra* note 5, at 3, states:

> Although [the Firm] . . . tested the new Risk Model, it did not conduct independent quality control over the programmers' work on the code. When these two programmers linked the Risk Model to the Optimizer, they made an error in the Optimizer's computer code. Although [the Firm]. . . conducted simulations involving the new Risk Model before rolling it out, these simulations did not detect the error. As a result, [the Firm]. . . did not detect the symp-

Over the next two years—from 2007 to 2009, during a period of extreme market volatility—the Firm (like many other quantitative managers) underperformed its benchmark indices.[155] By 2008, the Firm was fielding complaints from unhappy clients and actively engaged in research efforts to discover the cause of the underperformance, and of over-exposures (and under-exposures) to particular industries.[156] The effort was undertaken by a team located in London, not the California Research Group that had developed, and was primarily responsible for, the Firm Model.

The Firm Order indicates that in June of 2009, as researchers in London were closing in on the problem,[157] an employee in the California Research Group working on a revision to one of the three model components, discovered that since the last major revisions in 2007, because of scaling errors in the coding process used for the most recent revisions (i.e., using percentages rather than decimals—the same type of scaling error that occurred in the Mars Climate Orbiter)—the Optimizer had not incorporated "some" or "certain" of the intended common factor risks into the weightings recommended by the Firm Model (the "Model Error").[158] According to the Firm Order, the Model Error "effectively eliminated one of the key components of the Firm Model used for managing risk."[159]

The Firm Order stated that the employee revealed his findings during an internal presentation to a "Senior Official" and others in the California Research Group.[160] Another meeting was then held in which the Model Error again was discussed. Correcting the Model Error seemingly would have been a simple task. However, at these meetings, the employee and the Senior Official (who was either the actual or de facto

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toms of the error and did not discover the error itself until testing another new version of the Risk Model.

155. *Id.* at 4.

156. *Id.*

157. *Id.* at 3.

158. Firm Order, *supra* note 5, at 5. Due to this error, some factors apparently were weighted at 1/100 of their intended weights in this area of the Firm Model. The extent of the problem is not revealed in the Firm Order.

159. *Id.*

160. *Id.* at 2.

head of the California Research Group)[161] disagreed over the urgency of any correction. At one of the meetings, the Senior Official determined to delay correcting the Model Error in order to implement the coding changes in connection with planned revisions to the Firm Model that were scheduled to begin being implemented several months later.[162] The SEC's Orders also state that the Senior Official then instructed the employee and others in the California Research Group not to notify the Firm's Global Chief Investment Officer, the London team, or clients of the Model Error.[163]

By September of 2009, three months after the coding error was discovered, the models used for some of the Firm's clients had been modified to correct the coding error.[164] All of the other models were revised by November of 2009.[165] However, the Firm Order indicates that the Firm's Global Chief Investment Officer,[166] *all* of the Board members, and the Global Chief Executive Officer did not become aware of the coding error until November 2009.[167] Moreover, the SEC states in the Firm Order that the coding error was not revealed to clients who had expressed concern about general underperformance and overexposure to certain industries, which was a risk that was supposed to be partly controlled by the Optimizer.[168]

The Orders indicate that the coding error prevented a full integration of the Optimizer and may have contributed to at least a portion of the underperformance experienced by the Firm's clients during the roughly two-year period prior to the time it was corrected.[169] After all senior management of the Firm and all of its Board (there is no indication which Board members were not informed of the error, or whether they would have offered any insights into the error) were informed

161. *See* Rosenberg Order, *supra* note 6.
162. Firm Order, *supra* note 5, at 2.
163. *Id.*
164. *Id.*
165. *Id.*
166. *Cf.* David F. Larcker & Brian Tayan, *Risk Management Breakdown at AXA Rosenberg: The Curious Case of a Quant Manager Trusted Too Much*, Stan. Closer Look Series 3 (2013) (indicating that the Global Chief Investment Officer was informed of the error).
167. Firm Order, *supra* note 5, at 2.
168. *Id.* at 4.
169. *See* Rosenberg Order, *supra* note 6; Firm Order, *supra* note 5.

of the error, the Firm then began an internal investigation led by outside counsel and retained a well-regarded economic consulting firm to examine the potential effect of the error on performance.[170] The Firm Order indicates that in March of 2010, at the outset of a scheduled SEC examination, the Firm informed the SEC's exam staff of the Model Error.[171] Shortly thereafter, the Firm notified its clients of the Model Error.[172] However, because of the complexity of the analysis, the consulting firm retained to determine the extent of client losses attributable to the error was not able to present its findings until many months later.[173]

The Asset Manager and the California Research Group were registered under the Advisers Act. The Firm Order charges that, among other things, the Firm violated the securities laws by misrepresenting its controls,[174] not having controls that would have prevented the errors, misleading investors by failing to reveal that the basis for its underperformance may have "in part" been attributable to the error, not performing an adequate analysis of the error at the time it was discovered, and not correcting the Model Error in a timely manner.[175] Most damning perhaps in the eyes of the SEC, however, appears to have been the perception that the Senior Official, upon learning of the Model Error, attempted to hide it from fellow Board members, and others, by not notifying them "as soon as he should have."[176] The SEC concluded that this ultimately delayed consideration of the Model Error's effect, and of the necessary corrective action that may have prevented investor harm. Importantly, the SEC also found that the actions

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170. Firm Order, *supra* note 5, at 2.

171. According to the Firm Order, the decision to inform the SEC exam staff of the error was based on notice from the SEC of an impending investigation. *Id.* ("In late-March 2010, ARG disclosed the error to Commission examination staff after Commission examination staff informed ARG of an impending examination of ARIM and BRRC.").

172. *Id.*

173. *See id.* at 4.

174. Most of the significant violations were under the Advisers Act. However, because the Firm managed assets of mutual funds, the Firm also was charged with violating antifraud and other provisions of the Securities Act of 1933 and the Investment Company Act of 1940. *Id.* at 1.

175. *Id.* at 5.

176. Rosenberg Order, *supra* note 6, at 1.

of the Senior Official violated the Firm's code of ethics,[177] because they were not honest or fair, and that by not reporting the error to the Board and senior management of the Firm, the Senior Official also violated the Firm's escalation policies.[178]

In February 2011, the Firm settled the action, without admitting or denying the allegations, and was subject to a cease and desist order.[179] As a condition to the settlement, the Firm also agreed to reimburse investors roughly $217 million based on the consultant's determination of losses attributable to the Model Error, and paid a civil money penalty of approximately $27 million.[180] Notably, the Firm's alleged violations of the securities laws primarily were due to its actions following discovery of the coding error in the Firm Model as well as disclosures and omissions regarding its controls and risks associated with the Firm Model. However, the methodology approved by the SEC to calculate damages appears to have included the entire period in which the error was present from 2007–2009 (i.e., strict liability),[181] rather than the time frame after discovery of the Model Error.[182] While announcement of the SEC's en-

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177. As noted above, managers are required by Advisers Act Rule 204A-1 to have codes of ethics. The adopting release for the Rule notes that policies should emphasize "ideals for ethical conduct premised on fundamental princip[les] of openness, integrity, honesty and trust." However, the Rule focuses primarily on concrete activities, such as personal trading, and the adopting release for the Rule cites specific activity that would have caused a breach of fiduciary duty or involved fraudulent misrepresentations. *See* Investment Adviser Codes of Ethics, Advisers Act Release No. 2256 (July 2, 2004). Prior to the Orders, it is unlikely that in most instances managers would have regarded the failure to address a coding error, or to notify clients, as dishonest.

178. Firm Order, *supra* note 5, at 5.

179. *Id.* at 13.

180. As part of the settlement, the Firm was required to retain an Independent Compliance Consultant whose duties included, among other things: "review disclosures about the coding process, identify any weaknesses in that process, and make recommendations as to the appropriate disclosures relating to the coding of the Model to investors." *Id.* at 11.

181. "Strict liability" is referred to as "liability without fault" and defined as "[l]iability that does not depend on actual negligence or intent to harm, but that is based on the breach of an absolute duty to make something safe." *Strict Liability*, BLACK'S LAW DICTIONARY (9th ed. 2009).

182. The Firm Order, *supra* note 5, at 8, states:

> [The economic consultant]. . . developed a methodology not unacceptable to the Commission staff that (i) estimated the potential

forcement action against the Firm created controversy in the industry, a News Release published by the SEC contained statements by various members of the staff of the SEC's Division of Enforcement added further confusion regarding the implications of the Firm Order.[183]

Notably, statements in the Firm Order and News Release suggested that responsibility for design and adherence to coding standards is a compliance function, and that the failure to implement or follow operational controls is a compliance problem. For example, the SEC indicated that the Firm violated Section 206(4) and Rule 206(4)-7 of the Adviser's Act by failing to prevent the coding error.[184] The Firm Order states, among other things, that:

> "[b]ecause . . . [the Firm's] *compliance program* did not sufficiently identify and mitigate the risks associated with the Model's development, testing, and change control procedures, the coding error operated undetected for more than two years."[185]

The Orders also imply that the software development performed by the California Research Group should have been subject to compliance oversight.[186] Subsequent statements by SEC staff members have recommended that compliance of-

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greater exposure to common factor risk components for each month that a client account was impacted by the coding error; (ii) estimated the aggregate (across each of the affected factors) return implication of the potential greater exposure within each month and applied that return implication to an estimate of the monies invested in each portfolio in each client account within the month; and (iii) assumed that this estimated monthly impact would be reinvested back into the client's account to derive an estimate of that account's corrected return performance through the end of the account's error period.

183. *See* News Release, *supra* note 12.

184. Firm Order, *supra* note 5, at 8.

185. *Id.* (emphasis added).

186. The Firm Order presents the California Research Group as a "micro group," or "cabal," and was critical of the lack of compliance oversight over the Group. *Id.* at 3. However, as explained in note 68 and accompanying text, *supra*, independent research groups, which may be comparable to the "micro group" at the Firm, are not uncommon in business and among quantitative managers.

ficers at quantitative managers should have backgrounds in programming, or be able to read source code.[187]

b. A Deeper Look at the Facts Presented in the Orders

LTCM and the Orders illustrate problems that may occur when different types of imperfections are present in models. No action apparently was taken by the SEC against LTCM or its principals despite the arguable presence of design errors that led to large investor losses.[188] Nor did the SEC take enforcement action against most of the countless other traditional and quantitative managers whose strategies failed to work as predicted during the Global Financial Crisis, including many whose strategies were promoted as a hedge against market volatility.

The Firm Order, however, was trumpeted by the SEC in the press and at industry conferences in the year following its announcement. The SEC proclaimed that the Firm Order represented "the first ever arising from errors in a quantitative investment model," and that the action was a "high priority case involving quantitative investment models."[189]

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187. *See, e.g.*, Nina Mehta, *Quantitative Models Require More Discipline, SEC's Kurtas Says*, BLOOMBERG (Dec. 6, 2012). *See also* Erozan Kurtas, Assistant Director, SEC, Presentation at the SEC Compliance Outreach Program's National Seminar: Compliance and Risk Management in the 21st Century (Jan. 27, 2012) stating that:

> [m]ost compliance personnel do not have the background to understand, monitor or test the models. Models and Systems evolve faster than Risk or Compliance processes. In my opinion, traditional compliance need to become Quantitative Compliance: Financial Engineering requires Compliance Engineering.

This SEC staff statement, while more aspirational than others, generally is unrealistic and contradicts prior statements by the SEC itself, in the context of software design errors leading to regulatory violations, suggesting that if programmers write notes in English accompanying their code, compliance officers could assure that there is an accurate understanding in coding programs designed to comply with securities regulations. Morgan Stanley & Co., Exchange Act Release No. 55726, 90 SEC Docket 1625 (May 9, 2007).

188. LTCM apparently was not a registered investment adviser. However, the SEC had the ability to take action against the firm and its principals under other provisions of the securities laws.

189. *See* Robert Khuzami, Director, Div. of Enforcement, SEC, Public Statement by SEC Staff: Commission Credits Individual Under Cooperation Initiative (Mar. 19, 2012), https://www.sec.gov/news/public-statement/2012-spch031912rkhtm.

Because the Model Error involved a quantitative manager, the facts may have yielded an apparent opportunity for the SEC to promote the talent of its newly formed Quantitative Analytics Unit. Based on the manner in which the coding error was revealed (i.e., prior to an examination), and particularly in light of allegations regarding the apparent attempt to avoid any internal or client disclosure, the facts may have been unusually appealing to an SEC that may have been on the lookout for an action against a quantitative manager.[190] However, to understand the SEC's Orders, and their precedential value, it is helpful to examine the context of the Orders, both in terms of the Firm and the effect of external events.

i. Effect of the Global Financial Crisis

In the Orders, the SEC indicated that the Firm and Dr. Rosenberg made fraudulent statements to clients that attributed underperformance to market volatility, rather than a programming error.[191] The SEC emphasized investor complaints the Firm was receiving due to underperformance.[192] The Orders are not clear about the specific complaints. However, not mentioned, and perhaps not considered by the SEC at the time, is the fact that during the period in which the errors were present in the Firm Model (essentially during the Global Financial Crisis) across-the-board active quantitative managers, whose investment strategies were similar to the Firm, were fielding complaints from their investors that may have been like those referenced in the Orders.

All money managers, traditional as well as quantitative, and their clients were in a state of shock as they watched the value of the S&P 500 decline dramatically. Quantitative man-

190. The SEC received a lot of negative attention as a result of a high profile scandal involving hedge funds managed by Bernard Madoff. *See, e.g.*, SEC, Office of Investigations, Investigation of Failure of the SEC to Uncover Bernard Madoff's Ponzi Scheme—Public Version, Report No. 509 (Aug. 31, 2009), https://www.sec.gov/news/studies/2009/oig-509.pdf (detailing the lapses of judgment by SEC staff in failing to detect the massive Ponzi scheme). In the Madoff scandal, the SEC appeared to have been presented with strong economic evidence that the returns advertised by Mr. Madoff were not possible, yet it did not act to prevent the Ponzi scheme that resulted in billions of dollars of investor losses.

191. Firm Order, *supra* note 5, at 5.

192. *Id.* at 4.

agers relying on historical data, as a class, struggled to match even the rapidly declining performance of their benchmarks as their models failed to perform as predicted.[193] Moreover, quantitative managers significantly underperformed index strategies and more agile traditional managers with similar mandates.[194] The holdings in the portfolios of many quantitative managers turned out to be subject to similar market factors—potentially diluting the effect of their risk models and optimizers.[195]

Moreover, leverage and the fact that the models of many quantitative managers relied on the same factors, are rumored to have led the quantitative managers to exit positions at the same time—further driving down the price of securities.[196]

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193. *See, e.g.*, Alexis Xydias, *Quant Fund Assets Plunge After Strategies Underperform, Nomura Report Says*, BLOOMBERG NEWS (Nov. 9, 2010) (referencing a November 10, 2010 study by Bloomberg Holdings Inc., which indicated that a sample of 137 quant funds that actively managed equity funds lost twenty-four percent based on price since October 2007, compared with a twenty percent decline for the Standard & Poor's 500 Index over the same period); *see also, e.g.*, Julie Creswell, *Shrinking 'Quant' Funds Struggle to Revive Boom*, N.Y. TIMES (Aug. 19, 2010) (citing one study which noted that three quarters of quantitative managers lagged their peer group performance from mid-2007 to 2010).

194. *Id.* One highly regarded institutional manager that employed the Firm stated that while the Firm's performance "was below our expectations, [it] followed a similar trend to other quant managers" adding that "it [is] very difficult to tell whether there was any impact from this error." *See* Eleanor Laise, *AXA Rosenberg Reveals 'Coding Error,'* WALL ST. J. (Apr. 24, 2010 12:01 A.M.), https://www.wsj.com/articles/SB10001424052748704388304575202501743719416.

195. Numerous studies have looked at the Global Financial Crisis and the correlation among assets thought to provide diversification in portfolios. One study observed:

> Any attempt at "improving" portfolio diversification techniques . . . is also equally misleading if the goal is again to hope for protection in 2008-like market conditions. When there is simply no place to hide, even the most sophisticated portfolio diversification techniques are expected to fail.

Noël Amenc & Lionel Martellin, *In Diversification We Trust?* J. Portfolio Mgmt. 37 (Winter 2011).

196. *See* David Larrabee, *Does Quantitative Investing Have a Future?*, CFA INSTITUTE: ENTERPRISING INVESTOR (Apr. 12, 2012):

> It is widely believed that the primary reason quant funds stumbled badly beginning in mid-2007 was correlation between managers, compounded by leverage. Common metrics of value and momentum, the argument goes, led quants to hold similar stocks. Then,

Specifically, in the market conditions during the period of the Global Financial Crisis, the value-oriented quantitative models favored by a majority of quantitative managers—even those without errors in their models—were driven to overweight industries, such as financial services, in which stocks appeared to be underpriced from a historical perspective.[197] Even defensive strategies proved unreliable. Thus, from the perspective of investors, and the managers themselves, quantitative models appeared not to be working. Many managers during this period (not just the Firm) were actively engaged in research efforts intended to decouple their models from reliance on the same factors as their peers and to account for short-term volatility.

Total assets managed by quantitative funds had dropped dramatically by 2009 as quantitative managers struggled during the Global Financial Crisis.[198] In fact, based on their performance during this period, some speculated that almost half of the assets in quantitative strategies were withdrawn from managers by unhappy investors, and some even questioned the future of quantitative investing as a strategy.[199] Thus, the environment in which the errors in the Firm Model were discovered opens the possibility that other factors, and not simply the coding error, may have been the cause of individual investor complaints that resulted in the research undertaken by the Firm.

ii. Dr. Rosenberg's Role

In September 2011, seven months after the Firm Order was announced, the SEC confirmed rumors that Dr. Rosenberg, co-founder of the Firm, was the "Senior Official" referenced in the Firm Order.[200] Based on conduct largely (but not

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when stocks began to sell off, many quant managers found themselves racing for the exits at the same time.

197. In the financial services sector, for example, the securities of companies like Bear Stearns, Lehman Brothers, FNMA, and FHLMC, became almost worthless overnight, despite appearing as excellent value opportunities based on historical prices.

198. *See, e.g.*, Dan diBartolomeo, *The Near-Death Experience of Quant Asset Management*, NORTHFIELD INFO. SERVS. COMMENT (July 8, 2013).

199. *Id.*

200. *See generally* Rosenberg Order, *supra* note 6, at 3–4; Firm Order, *supra* note 5.

entirely) set forth in the February 2011 action, the SEC published a separate settled enforcement order in which Dr. Rosenberg agreed to a cease and desist order, a fine of $2.5 million, and a permanent bar from the industry.[201] Because there was a seven-month gap between the two SEC orders, the Rosenberg Order did not receive the same attention in the press and legal community. Though the reaction was much more limited, many members of the industry that either knew, or knew of, Dr. Rosenberg reacted in disbelief to the sanctions imposed by the SEC.

The following Section discusses the Rosenberg Order and allegations that may lead to misconceptions about the nature of decision-making at both quantitative and traditional managers. This portion and later portions of the Article also lead to a more fulsome discussion of managerial dynamics that is not reflected in the Orders, but is part of the reality of most organizations.

A. WAS DR. ROSENBERG THE REAL DECISION-MAKER?

The Orders are critical of the response of Dr. Rosenberg upon learning of the error. However, the Rosenberg Order makes clear that the action did not involve an instance in which a subordinate (even if termed a "Senior Official") hides a trading mistake from his or her superiors for fear of being disciplined or terminated. In fact, the Rosenberg Order indicates that he was more than simply a senior official: he was both Chairman of the Board of the Firm and its "intellectual leader."[202] Nor do the Orders suggest that the Firm was concealing an error from its clients to avoid a reimbursement payment.[203] The Rosenberg Order indicates that Dr. Rosenberg failed to disclose conflicts of interest in violation of Section 206 of the Advisers Act. However, the Orders are conspicuously silent on Dr. Rosenberg's motivation (whether corrupt

201. Rosenberg Order, *supra* note 6, at 5.

202. For example, it does not appear that Dr. Rosenberg reported to either the Firm's Global Chief Investment Officer or Global Chief Executive Officer. Moreover, Dr. Rosenberg had not committed the programming errors and the SEC makes abundantly clear that he had considerable stature in the investment community and within the Firm. The SEC does not offer any suggestion that Dr. Rosenberg's revelation of the error internally, and its immediate correction, would have produced any negative personal consequences for Dr. Rosenberg. *See generally* Rosenberg Order, *supra* note 6.

203. *See* Rosenberg Order, *supra* note 6; Firm Order, *supra* note 5.

or benign) for not revealing the error to the CEO or clients, and what conflicts Dr. Rosenberg may have faced.[204]

As described earlier, the Orders indicate that discovery of the error was raised and apparently discussed in multiple meetings within the California Research Group. The employee in the California Research Group who discovered the error, and argued in favor of informing others, appears to have been subordinate to Dr. Rosenberg who was de facto head of the Group.[205] As in other areas of finance, debate within research groups is not uncommon. The dispute between the employee and Dr. Rosenberg was not about correcting the error at all, but whether it should be corrected immediately or later, and whether others should be informed of the discovery.[206]

Despite the fact that there appear to have been at least two meetings within the California Research Group in which the error was discussed, depending on which of the Orders is read,[207] the SEC concluded that Dr. Rosenberg's decision was not based on adequate information, either because he "did not conduct or otherwise direct any analysis to estimate the error's impact," or there was a "rudimentary and limited analysis performed."[208] The Orders do not reveal the thinking of

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204. The Rosenberg Order indicates that Dr. Rosenberg held a twenty-one percent ownership interest in the Firm and shared in a portion of the advisory income received by the Firm. While it is reported that Dr. Rosenberg was not motivated by economic concerns at the time the error was discovered (apparently he also was teaching Buddhism), at least superficially this may have given him (perhaps more than any other individual associated with the Firm) a selfish interest in assuring that clients were not unhappy with the Firm's performance and that significant mistakes were appropriately addressed. There also is no suggestion in the Orders that Dr. Rosenberg or the Firm faced a conflict of interest because it was industry practice to compensate clients when programming errors were discovered, or that the Firm had specific policies addressing the manner in which such errors were to be addressed. In fact, there is no mention of the Firm's trade error policies (which more than likely did not encompass such errors). Although arguably a significant, unscheduled change in the Firm Model may have altered portfolios and generated questions from sophisticated investors, or internally, the Orders do not reflect that this concern was the basis for Dr. Rosenberg's decision. Rosenberg Order, *supra* note 6.

205. *Id.* at 7.

206. *Id.*

207. *See generally id.*; Firm Order, *supra* note 5

208. The two orders are seemingly inconsistent. The Rosenberg Order, *supra* note 6, at 4, stated:

others present at those meetings, or the discussion that ensued; nor do they credit Dr. Rosenberg for his vast investment management experience. Based on the description in the Orders, however, the dispute may have been no different than many disagreements among professionals.

b. Did the SEC Simply Disagree with the Investment Decision of Dr. Rosenberg?

As discussed below, while the evidence may exist (and may have been known to the SEC), there is no analysis in the Orders to suggest that the Model Error affected the Firm's ability to manage assets in a reasonable manner, or other than desired; or that the Firm was negligent or otherwise acted imprudently in managing assets. Nor does the SEC suggest the right amount of analysis that must be undertaken by a person of Dr. Rosenberg's experience when addressing model errors. By focusing on very general escalation standards, the SEC miscast the decision-making that occurs routinely within advisers, and also avoided a more central issue of whether or not Dr. Rosenberg's actions were reasonable in terms of the Firm's responsibilities to investors and in light of market conditions at the time. Dr. Rosenberg appeared to have both the power and authority to make decisions about correction of the Model Error.[209] Based on allegations in the Orders, which do not cite any evidence that his decision was unreasonable, or that he or the Firm were aware of a conflict of interest, it may seem that the SEC simply disagreed with the investment-related decisions of Dr. Rosenberg.

Apart from his role within the Firm (he was the de facto decision-maker), Dr. Rosenberg was esteemed within the in-

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> Rosenberg knew that that the Model was used to manage ARIM's and the Affiliated Advisers' client portfolios, and that the error could *potentially have adverse effects* on the performance of portfolios managed using the Model. *Yet, Rosenberg did not conduct or otherwise direct any analysis to estimate the error's impact. . . .* (Emphasis added).

In contrast to the Rosenberg Order, *supra* note 6, the Firm Order, *supra* note 5, at 7, notes that the California Research Group:

> failed to conduct any meaningful materiality analysis of the error's impact. BRRC knew that its clients used the Model to manage their clients' portfolios, and that the error *could potentially have adverse effects* on the performance of portfolios managed using the Model. *Yet, BRRC only performed rudimentary and limited analyses to estimate the error's impact.* (Emphasis added).

209. *See* discussion, *infra* at Section III.E.1.a.

dustry for his understanding of risk as a key component of investment returns.[210] As one commenter observed, Dr. Rosenberg's contribution to the field of quantitative management was to "develop, for the first time, models for implementing ideas in practice, and to place risk as the central framework for thinking about investing."[211] As noted earlier, the multi-factor models used by many managers today are based on his, and others', pioneering efforts. And while the Orders focused on Dr. Rosenberg, the team within the California Research Group, whom the SEC nefariously referred to as the "micro-group,"[212] also was highly regarded.

Also strikingly absent from the Orders is any evidence that investors would have benefitted if Dr. Rosenberg had decided to notify others within the Firm about the error. In fact, it is curious that while the SEC barred him from the industry, the Orders do not offer evidence that Dr. Rosenberg made a reckless, negligent, or unreasonable decision—or that if he had shared information with others, the decision to delay correction of the Model Error for several months to coincide with other revisions would have been any different.[213] In fact, the Rosenberg Order does not mention whether the revisions themselves were timed to correspond with planned rebalancing or scheduled events, or that the Firm would have otherwise disclosed planned model revisions to clients.

iii. How Significant Was the Model Error?

Despite the manner in which the SEC promoted the two enforcement actions, the losses ultimately attributed to the er-

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210. Whether Dr. Rosenberg ultimate investment decision was right or wrong—and there is no evidence in the Orders that he was wrong—and regardless of his motives, he was recognized as expert who more than likely had the knowledge and experience to make judgments about the effect on investor portfolios of the error under the circumstances, and to have determined the urgency of any error correction.

211. LINDSEY & SCHACHTER, *supra* note 10. In addition to the Firm, he also founded Barr Rosenberg Associates (now known as "MSCI BARRA, Inc.")—an organization that was sold to MSCI in 2004 and remains among the preeminent developers of third-party quantitative risk and investment models.

212. Firm Order, *supra* note 5, at 3.

213. One article, apparently based on sources with knowledge of the incident, indicates that Dr. Rosenberg did inform the Firm's Global Chief Investment Officer of the error. *See* Larcker & Tayan, *supra* note 166. *See also infra* note 334.

ror proved to be relatively minor in the context of losses that were experienced by investors during the Global Financial Crisis, raising questions about the significance of the Model Error and its materiality for disclosure purposes. For example, the Orders indicate that the economic consultant required by the Firm Order determined that the error adversely affected 608 of 1421 client portfolios and caused nearly $217 million in losses over the two years it was in place.[214] One article published following announcement of the Firm Order indicated that those damages accounted for only *22 basis points* (22/100 of one percent),[215] compared to the dramatic losses of investments during the Global Financial Crisis. A more favorable presentation of the same facts is that more than half of the Firm's client portfolios (fifty-six percent) either were not affected by the error, or benefited from the error and the decision made by Dr. Rosenberg.[216]

B. *Misunderstandings About Models, Quantitative Research Techniques, and Quantitative Managers*

The SEC ventured into uncharted waters in bringing actions against the Firm and Dr. Rosenberg—both of which were settled rather than litigated. Many were surprised by the Orders because the Firm and Dr. Rosenberg were highly regarded by other quantitative managers for the sophistication of their investment process. Within the industry, a number of managers also simmered over the mischaracterization of quantitative processes and the imposition of a seeming strict liability standard for errors in model development that were known to be commonplace and virtually unavoidable.[217]

In addition, there was dismay over the apparent heightened standard of conduct that the Orders suggested applied to quantitative managers versus the more reasonable standards

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214. Firm Order, *supra* note 5, at 1; Rosenberg Order, *supra* note 6, at 1. Moreover, the methodology used by the Consultant does not appear to give the Firm credit for losses that were *avoided* as a result of the error. *See supra* note 182.

215. *See* Larcker & Tayan, *supra* note 166 Assets managed by the Firm were reported to be from $70–$100 billion. *See* Douglas Appell, *AXA Rosenberg on Hot Seat Over its Delayed Response to Errors*, PENSIONS & INVS. (Apr. 10, 2010).

216. Firm Order, *supra* note 5, at 1.

217. Some managers also immediately amended their disclosure to account for model errors. *See Section* III.D.3.

that apply to the actions of their relatively more freewheeling brethren employing a traditional management style. Of specific concern to many may have been the impression that the SEC appeared to have second-guessed Dr. Rosenberg's assessment of the error's significance—in the context other controls employed by the Firm and the Global Financial Crisis—without presenting any evidence that the decision was wrong or imprudent, or that a different outcome would have resulted had he informed others of the error.

Because errors of varying significance are not uncommon in investment models used by quantitative managers or in the research used by traditional managers, there is a great deal at stake if the Orders are misunderstood and regarded as setting forth broader SEC policy, without the benefit of any informed comment from the industry affected by these statements.[218] While the SEC's internal policies may have evolved since the Orders,[219] managers and their legal counsel must consider the legal analysis in the Orders when drafting disclosure, developing compliance programs, and addressing the discovery of errors. Moreover, the precedent established by the Orders may serve as the basis for subsequent SEC enforcement action by the SEC, or policy discussions within the SEC.[220]

Because the action was settled, the Orders contain a limited analysis of the law, and only a brief summary of facts. A more detailed presentation of the facts favorable to both sides would have been offered in litigation. However, the issues raised by the Orders are far from black and white and the Orders may easily be misapplied as precedent for future SEC ac-

218. This Article expresses no view regarding the accuracy of the SEC's allegations in the Orders.

219. Informal reports indicate that the SEC staff is much more knowledgeable about quantitative practices than at the time of the Orders. The SEC is believed to have added significant resources in the areas of finance and economics. In addition, following the Orders, the SEC's examination staff is believed to have initiated a so-called "industry sweep" in which it sent form letters requesting detailed information from a number of quantitative managers, including those involved in high frequency trading. However, some believe that the SEC's examination staff has requested overly intrusive information about adviser's operations, including their data sources and models.

220. Following the Orders, the industry discussed standards for quantitative models. *See* CQA Working Draft White Paper, *supra* note 8.

tions.[221] Regardless of the facts known to the SEC or set forth in the Orders[222] (all of which are not presented in this Article), the Orders paint a confusing picture of quantitative investing and the law that needs to be examined more carefully. For example, the Orders and the standards announced in the accompanying News Release have raised concerns within the industry about the nature of reviews that must be undertaken in the face of coding errors, and the extent of a manager's reimbursement and disclosure obligations. In addition, language in the Orders, and both public statements by the SEC's staff and comments made during adviser exams, have strained to equate model errors with legal precedent and practices established by the SEC in the context of trading errors (discussed below). Moreover, while the Orders relate to an error in programming, they also represent the SEC's most significant attempt to grapple with conceptual issues raised by investment models in the context of important aspects of the Advisers Act.

Although the Orders enumerate a number of violations, the conduct cited by the SEC that represented securities law violations can be interpreted as falling roughly into the following categories:[223] the Firm's compliance procedures were inadequate because they allowed the programming error to oc-

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221. Barbash, a former director of the SEC's Division of Investment Management, observed in an article he co-authored with Massari, *supra* note 142, at 654:

> [T]he potential flaws in enforcement-action rulemaking can be seen in the rules effectively developed over time through settlements of cases brought under Section 206 of the Advisers Act. . . . [T]hese rules are often unclear as to their scope and often leave significant practical questions unanswered. Investment advisers and their counsel are left to divine, if not guess, the application in every day business life of basic fiduciary obligations . . . .

222. Respondents in a settled SEC enforcement action may or may not be able to review the language of the enforcement order prior to publication. Moreover, the SEC may face practical constraints in providing the full background to justify its decisions or the policy revealed in an enforcement order. Although counsel to the respondent often attempts to educate the SEC's enforcement staff, in this instance the SEC also may have been assisted by a former employee of the Firm. *See* SEC Credits Former Axa Rosenberg Executive for Substantial Cooperation During Investigation, Litig. Release No. 22298, 103 SEC Docket 976 (Mar. 19, 2012).

223. Both the actions against the Firm and Dr. Rosenberg were settled. *See id.* It is unknown whether there were additional facts available to the SEC, or

cur; the Firm and Dr. Rosenberg did not disclose the programming error to clients once it was discovered; the Firm did not correct the error promptly enough upon discovery; the Firm did not conduct a thorough enough analysis of the materiality of the programming error once discovered; and Dr. Rosenberg violated Firm policies, and therefore the federal securities laws, by not escalating information regarding the programming error "as soon as he should have."[224]

As discussed in more detail later, the Orders are based on three broad legal assumptions about investment models that should be examined more closely. Specifically, that the existence of errors in models is evidence of behavior that is not prudent, that trade error standards should be applied to model errors, and that the investment decisions of quantitative managers are subject to a different standard of care than the same decisions by traditional managers. In addition, many other statements in the Orders and News Release also might lead to basic factual misunderstandings about quantitative investing. For example, those reading the Orders might conclude, incorrectly, that:

- Errors (of many kinds) are unusual in the context of model development and application;
- Model governance only is a pre-implementation process, and therefore post-implementation controls, including the error correction process, can be ignored in evaluating the conduct of the manager;
- Models manage assets—overlooking both secondary controls (such as constraints on exposure to benchmark risk) and ongoing oversight of investor portfolios, and the important decisions of the manager in assuring that their investment program is implemented as intended;
- There is a predictable outcome if models are implemented to perfection (i.e., factors selected by the manager will add value);
- There is a single, perfect portfolio required to achieve the manager's and client's goals;

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a different legal analysis that is not shown in the Orders, that might have resulted in the same sanctions.

224. *See* Firm Order, *supra* note 5, at 8; Rosenberg Order, *supra* note 6, at 2

- Model errors must be resolved by the senior management of an adviser, or its board; and
- Oversight of model governance is a compliance function.

Apart from practical misunderstandings and a dubious legal foundation, a broader problem evident in the Orders is the liberal use of terminology that is common in the investment management industry, but which has a more nuanced meaning under the securities laws. This problem is illustrated in the way that the terms "error," "compliance," and "materiality" are used in the Orders. The following discussion addresses some of the possible misperceptions that might be inferred by those reading the Orders.[225] These concepts in most instances are interrelated and difficult to separate.

1. *Models Are Not "Error Free"*

One of the principal problems of the SEC's reasoning in the Orders is that it conflates pre-implementation controls over model development with the prudent management of investor assets. There are no allegations in the Orders that the Firm's investment program was not suitable for its clients, or that the Firm was not vigilant in monitoring positions and performance to assure that investor portfolios reflected the investment philosophy of the manager. While the Orders acknowledge that the Firm validated the model before placing it into production, there also is no suggestion that either those efforts, even if not perfect, were not reasonable or that post-implementation controls, even if not perfect, were not adequate.[226]

Notwithstanding examples of bugs, glitches, corrections, and crashes confronting every individual relying on technology, or major system outages reported in the news, the Orders appear to start with the assumption that investment models should be free of errors as a function of well-designed compliance controls. More broadly, the Orders suggest that it was misleading to disclose elements of the investment process (i.e.,

225. This analysis does not address all of the facts alleged in the SEC's Orders, but rather general concepts that are likely to cause confusion.

226. *See* Firm Order, *supra* note 5; Rosenberg Order, *supra* note 6.

use of optimizer) if the model is later determined to be flawed in some way.[227]

With respect to programming errors, as evident from the discussion earlier, even heroic efforts by governments employing practices that may not be commercially feasible do not result in error-free code. It is not realistic, therefore, to expect that a testing program will identify and prevent all possible coding errors ex ante, such as those revealed under the extreme volatility evident in the markets during the Global Financial Crisis. Despite the implementation of reasonable controls, many different types of errors may occur in the programming or model development process—some of which are foreseeable, and some not.[228] As one commenter noted in the context of third-party software:

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227. See Firm Order, *supra* note 5, at 9, which states:

> For the Risk Model rolled out in April 2007, . . . [the Firm] failed to conduct sufficient quality control over the coding process before putting that model into production. The coding process itself represented a serious risk exposure for BRRC and its clients because *accurate coding is required* for the Model to function properly and as represented to clients. By failing to adopt and implement policies and procedures reasonably designed to ensure that it did not make false and misleading statements and/or omissions to clients and investors, including failing to ensure that the Model performed as represented, in violation of the antifraud provisions in the Advisers Act.

Id. (emphasis added).

228. The notion that a model must be error-free is contrary to the position that the SEC has taken in its policies governing the most critical aspects of the securities markets. In 2014, for example, the SEC adopted Regulation SCI under the Exchange Act, which sets forth the SEC's new automation policy for exchanges, registered clearing organizations, and trading centers. Regulation Systems Compliance and Integrity, Exchange Act Release No. 73639, 2014 WL 6850916, 470 (Nov. 19, 2014) [hereinafter Regulation SCI]. The adopting release for Regulation SCI chronicles numerous instances in which market outages have occurred because of programming errors. *Id.* The SEC also noted that the new rules for these critical market elements do "not require an entity to guarantee flawless systems." *Id.*; *see also* Regulation Automated Trading, RIN 3038-AD52, 80 Fed. Reg. 78823 (proposed Dec. 17, 2015) [hereinafter Proposed CFTC Regulation Automated Trading]; Regulation Automated Trading RIN 3038–AD52, 81 Fed. Reg. 227 (proposed Nov. 4 2016) (supplemental notice of proposed rulemaking) [hereinafter SNPRM of Proposed CFTC Regulation AT], http://www.cftc.gov/idc/groups/public/@newsroom/documents /file/federalregister110416.pdf.

> "It is generally foreseeable that any complex software will have 'bugs.' The problem is that it is not foreseeable exactly what those bugs will be, or what the impact of those bugs will be on the licensee or a third party."[229]

2. *The Model Governance Process Includes Monitoring, Mitigation Efforts, and Other Post-Implementation Actions*

Managers employ resilient processes because they anticipate errors.[230] Any analysis of model errors for fiduciary purposes, including under the Advisers Act, should not focus solely on the presence of a model error[231] and ignore secondary controls, including post-implementation oversight of models and portfolios, which is recognized both as a critical element of model governance and as an investment management function. It is striking, for example, that the Orders do not mention the likely intentional decisions made by the Firm's investment professionals in the ongoing monitoring of transparent characteristics of the portfolios and market developments, which should have prevented significant variations from the manager's intended investment program. In fact, notably absent from the facts alleged in SEC's Orders is any mention of the likely daily, weekly, and monthly review of client portfolios that should have served as a separate, independent

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229. Michael D. Scott, *Tort Liability for Vendors of Insecure Software: Has the Time Finally Come?*, 67 MD. L. REV. 425, 443 (2008) (citations omitted).

230. At many managers, for example, constraints imposed through the optimization process or elsewhere may dictate the minimum and maximum exposure to factors. Thus, even if an error caused a model to assign zero weight to a factor, the constraint imposed by the manager may have forced the model to have a minimum exposure to the factor in order to limit active risk versus the target benchmark. By the same token, a constraint, or investment guideline, also may limit overexposure to factors, potentially diluting the effect of so-called "value traps" that appeared during the Global Financial Crisis or other errors. *See supra* note 61.

231. Surprisingly, in the Firm Order, *supra* note 5, the SEC glossed over the fact that the Firm validated the Model changes prior to implementation and undertook research to determine causes of underperformance, which reflect prudent behavior. After the error was discovered, Dr. Rosenberg also appears to have modified the California Research Group's controls to assure that similar types of programming errors would not occur in the future. (Dr, Rosenberg is quoted in both Orders as stating that "mistakes if there were any will not be made in the future"). Both of these actions would be part of a reasonable model governance process.

control over errors that might have affected the Firm Model's signals.

The role of model oversight is illustrated in guidance published by the Office of Comptroller of the Currency on model risk management:

> Even with skilled modeling and robust validation, model risk cannot be eliminated, so other tools should be used to manage model risk effectively. Among these are establishing limits on model use, monitoring model performance, adjusting or revising models over time, and supplementing model results with other analysis and information.[232]

The discovery of errors post-implementation does not imply that either a manager's governance structure or investment process was flawed, that its controls were not reasonable, or that the errors ultimately lead to an adviser managing a portfolio in a manner other than it intended.[233] In fact, because errors are unavoidable and anticipated, the detection and remediation of an error—whether due to monitoring efforts to detect and address errors, post-implementation validation efforts, internal audits, or other means—are part of the manager's control environment and may actually reveal the prudent application of its controls.

3. *Advisers Exercise Investment Discretion—Not Models*

As discussed more fully later, models and model signals are properly regarded as investment research that is no different analytically than the research relied on by traditional managers. Quantitative management is not a completely robotic process. There is a subjective element, similar to that of traditional managers, that is an inherent part of the development, application, evaluation, and enhancement of models used by quantitative managers. For this reason, as mentioned else-

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232. OCC Bulletin, *supra* note 71 While shortly after the Orders were made public, commenters discussed the use of "coding buddies" and independent audits to prevent and detect errors, the OCC Bulletin more accurately places those controls in the context of the larger model governance process.

233. As suggested elsewhere, intertwined with model governance, but separate, is the management of the investors' assets. Institutional managers typically follow a process that is calculated to assure that a portfolio is managed in a manner consistent with their investment intent.

where, models are accurately described as "decision support tools."[234] The false notion that models, and not advisers, manage portfolios is a common misconception that also can be found in a statement in the Orders which declares that the Firm Model allowed the Firm "to make investment decisions largely without human interaction."[235]

Regardless of the degree of automation in a manager's investment process, the adviser (and not models) signs investment management agreements, is vested with the authority to exercise discretion in managing client assets, and has fiduciary obligations. Whether they use third-party models, or proprietary models, investment personnel at quantitative firms, like those at traditional managers, make judgments about investment theories, data sets, and the investment strategy expressed in their models. Portfolio managers and investment committees also calibrate models, and interpret and apply model signals in the context of managing individual portfolios; and exercise discretion in determining when to intervene and revise or enhance their models, add new data sources, rebalance portfolio positions, or make other changes to portfolios that they manage based on hard or soft guidelines. In many index funds, for example, managers define the rules for the strategies; and in "smart beta" strategies, among others, they define the factors that they will emphasize. Thus, while quantitative models inform the decision-maker, they do not manage client assets.

Even though an investment adviser may implement an algorithmic trading or investment strategy that is perceived to be fully automated, the adviser still continues to exercise investment discretion. As an example, the same kind of human decision-making occurs in the implementation of high frequency trading firms that rely on microsecond executions with straight through input.[236] The CFTC provided the following

234. As one commenter noted in reference to the Global Financial Crisis: "[Q]uantitative tools are critical aids for supporting risk management, but quantitative tools alone are no substitute for judgment, wisdom, and knowledge." Thomas S. Coleman, 6 Uses and Limitations of Quantitative Techniques, INV. RISK & PERFORMANCE FEATURE ARTICLES, 1, 1 (Mar. 2012) (CFA Inst. ed.).

235. Firm Order, *supra* note 5, at 4.

236. In fact, although quantitative models can capture and process information much more rapidly than traditional managers, much of the informa-

illustration on the importance of human judgment in a release on high frequency trading by Automated Trading Systems (ATS):

> In automated trading, humans design and test ATSs, establish decision criteria, manage implementation, and intervene when technology systems fail. ATS designers must identify the range of market conditions that an ATS could reasonably face, and determine the range of permissible responses by the ATS to each condition. Designers must also consider the array of information that ATS operators will need to effectively monitor their ATSs and the markets in which their ATSs operate. ATS operators, in turn, must be prepared to intervene when market conditions are outside of an ATS's design parameters, when an ATS's trading strategy must be modified, or when an ATS appears to be malfunctioning and must be shut down . . . .[237]

4. *Portfolios Constructed Reflect the Manager's Intent at a Point in Time*

As suggested above, the observable results of a model are a key determinant of whether or not it is operating as anticipated—and that a client portfolio is being managed in the manner intended. If the manager is not satisfied with the portfolios constructed, it may intervene in a variety of ways. Thus, despite the presence of many different types of errors or mistakes in judgment, portfolios actually constructed by quantitative managers will manifest their intention in most instances. As emphasized above, while models are important research tools used by an adviser as part of the investment decision-making process, the adviser, and not the model, ultimately is responsible for management of the portfolio.[238]

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tion will not result in an immediate transaction because many managers do not trade frequently, and because the information is only one data point and must be compared to other data analyzed by the manager in the context of that security and of other stocks in the same industry.

237. Concept Release on Risk Controls and System Safeguards for Automated Trading Environments, 78 Fed. Reg. 56542 (proposed Sept. 12, 2013).

238. SEC enforcement orders, including the Orders, routinely contain a boilerplate statement indicating that a person acts "willfully" in violating the

At both quantitative and traditional managers, the success of an investment management process relies on the manager's skill and judgment. Consistent with any disclosure provided to investors, both quantitative and traditional managers can choose to rely on some third-party research, but not others; conduct their own research; or ignore research results as part of the investment decision-making process. As a fiduciary, the manager's judgment need not prove wise in every instance and there is no single correct conclusion. In fact, the securities markets only are efficient because of the differing, reasonable views of managers exercising discretion.

No laws state that a traditional equity manager must immediately dispose of a holding based on a change in a third-party analyst's opinion. For this reason, the same facts triggering a sell recommendation by one research analyst, may signal a buying opportunity to other analysts. Not uncommonly, the market will ultimately reach a different conclusion about an investment opportunity over a particular period of time even with an error-free model. By the same token, the effect of an error (including the urgency of correcting the error) may not be of critical concern to the manager—who does not have a crystal ball—if it ultimately is satisfied that a portfolio constructed evidences its investment views. Thus, even with the presence of known errors, in many cases managers can prudently manage portfolios consistent with their objectives.

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securities laws if he or she knows what they are doing—whether or not they are aware that they are violating the law. It is unlikely that a manager could argue that it did not intend to manage, or was not "willful" in managing, a portfolio in a particular manner—despite the presence of model errors—when it had control over the models and ultimately was responsible for investment decisions. *Compare* Gregory Scopino, *Preparing Financial Regulation for the Second Machine Age: The Need for Oversight of Digital Intermediaries in the Futures Market*, 2 COLUM. BUS. L. REV. 439 (2015) (discussing the CFTC Release, artificial intelligence, and "moral agency" in the context of regulation and the enforcement of laws in futures markets), *and* Gregory Scopino, *Do Automated Trading Systems Dream of Manipulating the Price of Futures Contracts? Policing Markets for Improper Trading Practices by Algorithmic Robots*, 67 FLA. L. REV. 221 (2015) (examining various mental states from "strict liability" to "specific intent" in the context of models and the anti-manipulation provisions of the Commodity Exchange Act).

a. Car and Driver Metaphor

The following metaphor also serves as an example of the role of investment models in the investment decision-making process, which is discussed more thoroughly below.

A driver (i.e., adviser) runs a car service (i.e., an investment strategy). He or she drives the car advertised (i.e., the investment model or strategy) to clients—a limousine and not an economy car (i.e., the adviser is truthful about the car provided). The car is designed to handle a variety of road conditions, but is intended to be driven on highways. The car is subject to regularly scheduled maintenance (i.e., the driver is prudent). However, it also is known that cars break down due to wear and defects in manufacture and that unusual conditions, such as potholes, may cause damage to the vehicle.

While driving the car, the driver may notice that it is pulling slightly to the right (i.e., model recommendations). He or she might correct the car by turning the steering wheel more to the left to maintain its position on the road. Once the issue is noted, however, the driver may want look at all the conditions on the road (i.e., other sources of information) and wait to see if the road is canted (i.e., if the market is irrational), and the problem will be corrected once the car is on a level stretch of road; or whether there is a problem with the steering that needs to be addressed (e.g., a tire is out of alignment or needs more air).

If the problem is severe in the driver's judgment (i.e., investment decision-making discretion) or is potentially an impediment to driving safely (i.e., managing the portfolio as intended) then the driver may rush to a mechanic to have it repaired. Otherwise, the driver may decide to drive while slightly counter-steering (i.e., to mitigate the problem so that it does not affect his or her ability to manage portfolios) and have a mechanic look at the problem when he or she takes the car in for scheduled maintenance in a week. The driver (i.e., the adviser), not the car (i.e., the investment model), makes the decisions.

Once the car is being serviced, if the problem is not severe and the mechanic informs the driver that one tire is causing the problem, the driver may delay replacing that tire if he or she plans on replacing all of the tires next month (i.e., resource allocation). If the tire is replaced before returning the

car to the driver, the mechanic may take the car for a "test drive" and use other diagnostic tools (i.e., back-tests) to assure that the car is safe and that replacing the tire has corrected the problem (i.e., the repair process may take time).

The driver does not promise passengers that the car's wheels will never be out of alignment. The driver also does not tell passengers when the car's wheels are out of alignment, or inform them of other problems that the car might have, since they do not interfere with his or her ability to perform the task that he or she is hired to accomplish. If the passenger asked, the driver would disclose that the car was pulling to the right or left. In the meantime, even while the wheels are out of alignment, the passengers do not notice the problem and reach their destination safely. However, if the ride is uncomfortable, and the passengers do not reach their destination on time, they may select another driver in the future. This prospect serves as an incentive for the driver to follow reasonable procedures to keep the car properly maintained.

5. *Advisers Are Not Required to Accurately Predict the Future*

As discussed earlier, investment outcome is not the fiduciary standard. However, the Orders create the misimpression that the effect of an error on investment performance will be negative, and that not correcting an error immediately is imprudent.[239] An expression used in statistics is "correlation does not imply causation"—which emphasizes that a correlation between two variables does not necessarily imply that one is the cause of the other.[240] This potential problem is evident in the Orders both in the notion that the Model Error was the "cause" of investor complaints and that the Model Error "caused" investor losses.[241]

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239. *See* Firm Order, *supra* note 5; Rosenberg Order, *supra* note 6.

240. In Latin, this logical fallacy is referred to as post hoc ergo propter hoc—"after this, therefore because of this."

241. Firm Order, *supra* note 5, at 2; Rosenberg Order, *supra* note 6, at 2. As shown earlier, most investors were generally unhappy with their returns during the Global Financial Crisis and specifically with the returns generated by quantitative managers versus traditional managers. *See supra* Section II.A.b.3.i. While a model error may contribute to losses, an error is not responsible for market movements that cannot be known ex ante by the manager. As Sir Isaac Newton reportedly stated (after experiencing investment losses in 1720): "I can calculate the motion of heavenly bodies but not the

This causal fallacy appears in statements made in the Orders and News Release that models should work as "predicted;" that there are "potentially adverse" consequences of not correcting an error, while ignoring the "potentially beneficial" or "potentially neutral" effect of not correcting an error; and that the Model Error—rather than the market—"caused" investors to experience losses.[242] While an error may exist in a model, it is a fallacy to assume that because the error is correlated with market movements it is the cause of investor losses. A more thorough analysis (not presented in the Orders) is required.[243]

As discussed later, this fallacy is evident in the SEC's implication that in the Orders the Model Error should have been addressed promptly to avoid investor losses. Depending on the strategy, model errors actually may increase returns over a period of time. Similarly, intended elements of a model, as well as planned enhancements, may have a negative effect on performance over a particular period. As mentioned throughout this Article, the randomness of market movements means that when relying on statistical models, a manager cannot be certain that the optimal variables or parameters have been chosen over a period of time. Statements in the Orders may be interpreted in a way that is not consistent with the reality of what is possible and contradict the wealth of law indicating that a fiduciary acting in good faith only is required to exercise reasonable judgment—and not required to prophesize movement of the markets. This may mean that in some cases, a reasonable manager will choose to delay correcting, or to not correct, a known error.

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madness of people." PATTERSON, *supra* note 10, at 12; *see also* Tom C.W. Lin, *Reasonable Investor(s)*, 95 B.U. L. Rev. 461 (2015) (discussing reasonable investors and market performance).

242. Firm Order, *supra* note 5, at 2, 7–8; Rosenberg Order, *supra* note 6, at 2, 5; News Release, *supra* note 12. The consultant retained by the Firm as a condition to settlement with the SEC found that the Model Error contributed to only a very minor portion of the losses experienced by the Firm's clients during the Global Financial Crisis. *See supra* Section II.A.3.b.iii.

243. In some instances, however, an error in a model or a deliberate decision of the manager (such as with respect to the use of leverage or derivatives) may expose an investor to greater risk than intended. But the analysis is contextual.

6. *There Are No "Model" or "Perfect" Portfolios*

The Orders also can foster the misconception that there is only one way of achieving the manager's goals. As illustrated previously, there are no model portfolios and a wide range of investments often may be acceptable to the manager in effecting its strategy. The Orders, however, are emblematic of the falsehood that there is a precise combination or mix of assets that are necessary to implement the adviser's strategy, ignoring that fact that the investment characteristics of a security generally begin to evolve the moment that it is recommended by a model. The notion that perfect portfolios exist has been described as a myth:

> Efficient portfolios exist in theory, but not in practice. Even if you create an efficient portfolio, as the market opens, using all of the information that you have at that moment, it becomes inefficient as soon as prices move (and portfolio weights change), or new information comes in (and the expected returns and risks change).[244]

As noted earlier, managers contemplate that drift will occur due to price changes and other factors. However, they may not rebalance the portfolio, or trade, except on a periodic basis. Because the manager cannot predict the future, an investment ranked in the top decile by an imperfect model may be just as acceptable as an investment ranked in the eighth or ninth decile by a perfect model.[245] Thus, in many cases model errors will cancel out at the portfolio level because of other constraints or the portfolio manager's exercise of judgment, and will not affect the manager's ability to execute its strategy in the manner it intends.

III.
Appropriate Legal Standards for Examining Model Errors

Prior to the Orders, the SEC had taken enforcement action against quantitative managers in instances in which the

244. Frances Cowell, Risk-Based Investment Management in Practice 229 (2d ed. 2013).

245. Differences in cash flows among accounts may also mean that individual accounts will hold different investments.

adviser had not actually created the model that it disclosed to investors.[246] Since perfection is unattainable in model development, there is a wide gulf between those cases and ones, such as the Orders, in which a model has an error and the SEC believes it simply is not working as predicted. The Orders raise the difficult issue of determining when an error would be so profound, in the context of a manager's other processes, that the manager's general disclosure that it has a model, or controls for risk, becomes inaccurate.[247] Importantly, the Orders also suggest that one type of error is different than another, and that quantitative managers have a higher standard of care than traditional managers.

In statistics, a model that is "underfit" is flawed and often will show a strong and inaccurate bias. Underfitting occurs when the data used for training a model is not the same as the type of information that is being considered in the future (e.g., we assume all swans are white because we have not seen a black swan). Underfitting can occur, for example, when a model has memorized simple training data and developed basic rules that do not allow it to generalize from a trend. Models with this flaw typically will fail when applied to new or unseen data that is more complex. Very simply, in the relevant context, if all prior SEC enforcement actions involving advisers' "errors" related solely to errors in trade execution, there may be a tendency (or "bias") in favor of analyzing other types of errors (i.e., model errors) in the same fashion as trade errors.

As explained below, however, investment model errors are very different than trade errors. Use of the term "error" in describing mistakes in coding or model development easily can be viewed out of context. Among other things, the label "error" may create an incorrect assumption about the precision of the model development process and a misplaced focus on model development and coding rather than the adviser's function as an asset manager and the role of models as research tools in the investment management process.

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246. *See supra* note 143 for examples.

247. For example, even if an error is significant, but latent, it may have an effect in some environments but not others; or, as with a traditional manager, the effect of the error may be obviated by other research relied on by the manager.

A. *Models Are "Research" that Inform the Investment Decisions of Managers*

From both the perspective of the investment industry, and from a securities law perspective, models are research or decision support tools used by the manager in connection with its exercise of investment discretion. In 1975, Congress embraced the evolution of research when it added Section 28(e) to the Exchange Act and specifically recognized that "computer analyses of securities portfolios" falls within the definition of "research" that may be acquired by an investment manager using soft dollars—just as traditional research reports.[248] However, the scope of software that is covered by the safe harbor in Section 28(e) for research was a subject of ongoing debate as technology evolved.

In 2006, after an extensive public comment process, the SEC issued an interpretive release[249] formally acknowledging that models are research for purposes of Section 28(e) if they "provide lawful and appropriate assistance to an investment manager exercising investment discretion over accounts."[250]

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248. *See* AN ACT TO AMEND THE SECURITIES EXCHANGE ACT OF 1943, S. REP. NO. 94-75, at 71 (1975) (Report from the Committee on Banking, Housing, and Urban Affairs). As far back as 1975 it was evident in congressional statements that, from a legal perspective, models are "research" under the securities laws, and that the same information can be presented as a written research report provided to a traditional manager or be made available in an electronic format through models. *See id.*

249. *See, e.g.*, Commission Guidance Regarding Client Commission Practices under Section 28(e), Exchange Act Release No. 54165, 17 C.F.R. 241 (July 18, 2006) [hereinafter 28(e) Interpretive Release]; *see also* Interpretive Release Concerning the Scope of Section 28(e), Exchange Act Release No. 23170, 17 C.F.R. 241 (Apr. 23, 1986); Interpretations of Section 28(e) of the Securities Exchange Act of 1934; Use of Commission Payments by Fiduciaries, Exchange Act Release No. 12251, 17 C.F.R. 241 (Mar. 24, 1976). The same interpretation has been embraced by the Department of Labor for ERISA purposes. *See, e.g.*, Charles Lerner, SEC No-Action Letter, Fed. Sec. L. Rep. ¶ 78,871 (Oct. 25, 1988) [hereinafter Lerner Letter]; *see also* Statement of Policies Concerning Soft Dollar and Directed Commission Arrangements, Department of Labor ERISA Technical Release No. 86-1 (May 22, 1986).

250. In relevant part, Section 28(e)(3) states:

> a person provides brokerage and research services insofar as he—(A) furnishes advice, either directly or through publications or writings, as to the value of securities, the advisability of investing in, purchasing, or selling securities, and the availability of securities or purchasers or sellers of securities; (B) furnishes analyses and reports concerning issuers, industries, securities, economic factors

The statutory test outlined by the SEC is whether the model "provides analyses of securities portfolios" and "reflects the expression of reasoning or knowledge" with respect to "the value of securities, the advisability of investing in, purchasing, or selling securities . . . ."[251] Investment models, such as those described in the Orders, as well as quantitative research techniques, are properly regarded from a legal perspective as research tools used by the manager in connection with its exercise of investment discretion.[252] Similarly, systems that allow a manager to monitor performance, including much of the data that the manager receives as part of the model application, development, and ongoing monitoring process, also would be regarded as research and are part of the investment-decision process.[253]

Correctly viewing models as research or decision-support tools resolves many of the problems that are discussed later in this Article. The research elements of models include the analysis underlying the model, as well as the programming of the models and the efforts to correct any errors in order to improve future decision-making. These activities are analogous

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and trends, portfolio strategy, and the performance of accounts; or . . . .

Securities Exchange Act of 1934 § 28(e)(3), 15 U.S.C. § 78bb(e)(3).

251. *See* 28(e) Interpretive Release, *supra* note 249, at 27, 29 ("Software that provides analyses of securities portfolios is ["research" and therefore] eligible under the safe harbor because it reflects the expression of reasoning or knowledge relating to subject matter . . . .").

252. More broadly, the 28(e) Interpretive Release examined "market research" and "data" in the context of the terms "data" and "market analysis." *Id.* at 34–36. The SEC specifically noted that modern research services provided electronically may be different than traditional research reports and advice historically provided by brokers. *Id.* It further noted that company and economic data used for models are "research" and may be purchased with soft dollars. *Id.* at 35; *see also* Bundled Brokerage and Soft Commission Arrangements, Financial Services Authority Policy Statement No. 04/23 (Nov. 2004) (U.K.) (acknowledgement by the United Kingdom's securities regulator that that models may be "research" services if they offer "original analysis and meaningful conclusions on investment and trading decisions . . . .").

253. The entire scope of model development and governance, which shapes the way portfolios are managed, should be considered part of the research function within managers. By analogy, the pricing of third-party research models that qualify as "research" under Section 28 (e) also reflects the cost to the vendor of design, development, and maintenance.

to the research efforts and investment decision-making that occurs at traditional managers.

B. *Legal Concepts Involving Trade Errors and Other Errors Are Poorly Suited to Analyzing Investment Model Errors*

If the Firm Model was viewed as research, the SEC's analysis of the facts and law applicable to the Model Errors might have been very different. However, both statements in the Orders and subsequent comments by SEC staff suggest that the Model Error was examined in the context of precedent derived from simple trading errors rather than research. Many statements in the Orders can be more easily understood in the context of the inappropriate application of precedent involving trade errors.

The term "trading error" commonly refers to an error in the execution of an order due to a failure to properly implement a portfolio manager's instructions, such as purchasing rather than selling a security, effecting transactions in the wrong amount or for the wrong account, or investing in individual securities that are not permitted in an account due to client instructions or otherwise.[254] The sharp distinction between what is research and what is an execution-related trade error is evident in the temporal standard adopted by the SEC under Section 28(e). The SEC stated in the 28(e) Interpretive Release that "[r]esearch services include services provided before the communication of an order" for execution.[255]

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254. Included within the trade error definition used in this Article are account restrictions that may be present as a result of client guidelines, laws, or prospectus or other disclosure (e.g., limits on positions or sector concentrations). Some advisers' trade error policies specifically exclude from the definition of a "trade error" in their policies, errors that occur in connection with the investment decision-making process.

255. Section 28(e) Interpretive Release, *supra* note 249, at 41. While the SEC's statement applies to orders communicated to a broker, it is clear that model output for investment purposes would be distinct from internal trade instructions that are routed to a trading desk once that investment decision has occurred. Model errors that may occur prior to an investment decision could include those relating to investment restrictions or other limitations on investments not being appropriately coded. *See* Western Asset Mgmt. Co., Advisers Act Release No. 3763, 108 S.E.C. Docket 673 (Jan. 27, 2014) [hereinafter WAM Order]. (Errors in pre-trade compliance model resulted in adviser failing to adhere to an issuer's investment restrictions). The distinction between investment models and execution models also is emphasized in the

Thus, order routing and trade execution software, or models used in pre-trade compliance, may not be considered "research," while models such as the Firm Model, that assist a manager in determining which security to purchase, sell, or hold would be considered research.[256]

With respect to trade errors, the SEC has taken the position that the antifraud provisions of the Advisers Act, along with general fiduciary obligations, require that "consistent with industry practice" a loss resulting from trade errors should not be borne by the adviser's clients.[257] Advisers therefore may (in some cases) be subject to liability, similar to strict liability, for trade errors. The SEC also implicitly requires advisers to have specific policies or procedures for determining how trade errors will be handled.[258] For this reason, trading errors fre-

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industry comments on the CFTC's Proposed CFTC Regulation Automated Trading, *supra* note 228.

The lines between what is an investment decision (part of the manager's trading strategy) and what is "trading" may be blurred in the context of high frequency trading. Trading algorithms that are part of a manager's investment strategy because they are designed to generate "alpha" also should be considered "research" and an equal part of the investment decision-making function. In the industry, these types of alpha generating trade execution models may be referred to as the "little game" versus the "big game" represented by the portfolio management models.

256. *See* WAM Order, *supra* note 255 (labeled by the SEC as a "model error" action).

257. *See, e.g.*, Lerner Letter, *supra* note 249 (an investment adviser "is responsible for any losses resulting from an inaccurate or erroneous order placed for an advised account"). However, the letter also noted that contractual provisions may modify these responsibilities. *Id.* at n.2. For example, as discussed earlier, the standard of care of an adviser is typically negotiated between the adviser and the client and set forth in the advisory agreement.

258. Robert W. Helm & Megan C. Johnson, *Dealing with Investment Errors*, 20 INV. LAW. (2013) ("Although not required by the securities laws, it is a generally accepted practice for investment advisers to adopt policies and procedures that provide guidelines for resolving trade errors."); *see also, e.g.*, Michael T. Jackson, Advisers Act Release No. 2374, 85 SEC Docket 357 (Apr. 6, 2005).

Although advisers are not specifically required by the Advisers Act and Rule 206(4)-7 to have policies regarding trade errors, the SEC has implied in enforcement orders that advisers must have such policies. An adviser's compliance department also may monitor transactions to assure that they adhere to investment guidelines disclosed to investors, as well as any client-specific limitations. Compliance personnel generally act to assure that an adviser does not violate any specific legal limitations found in the Advisers Act, the 1940 Act, ERISA, or other provisions of the securities laws, etc.

quently are addressed in investment advisory agreements and the regulatory compliance procedures of managers.[259]

When they occur, in many cases, trade mistakes can be discovered and corrected before the end of the securities settlement cycle. If not, however, a manager may simply sell a security purchased in error, or purchase the correct security.[260] Managers typically act quickly to remedy a trade error to limit any potential losses that they might incur due to the error. However, client compensation decisions relating to trade errors often are based on business considerations[261] and in-

259. SEC examiners often request records relating to any trading errors. Advisers' trade error policies and procedures normally indicate that the adviser is subject to a fiduciary duty as well as contractual obligations in its investment management agreements that impose a standard of care. Although individual policies vary significantly from adviser-to-adviser based on a variety of factors, they normally are expressed as general guidelines. Almost all advisers and their counsel consider the actual analysis of a potential trade error, and the adviser's responsibility, to be a highly fact-specific examination. *See* Helm & Johnson, *supra* note 258 (containing an excellent overview of the law applicable to trade errors and the relevant theories for calculating damages).

260. As shown earlier, many modern managers are relatively agnostic within a broad range of securities that might be purchased for a portfolio to implement their strategy, so normally there is no "perfect" stock. *See generally supra* Section I.A. For this reason, it is questionable whether traditional notions of the manager reimbursing a client for losses attributable to the idiosyncratic performance of purchasing the "wrong" security are economically justifiable based on the "harm" caused to investors. Even if a manager bought *Y* security instead of *X*, both securities may be equally acceptable at the portfolio level. The driver metaphor, *supra* Section II.B.4.a, also may be used to illustrate the uncertainty of outcomes over a particular period of time. For example, there may be several equally acceptable routes to a destination (i.e., substitution candidates). On any particular day, depending on traffic conditions, it may not be predictable which route will be the most efficient. However, if the driver misses the exit to his first choice, he or she may take an alternative route. The driver may encounter an immediate traffic jam on the alternative route, which then clears up, but a much lengthier traffic jam may have awaited the driver closer to the destination on the first route. In fact, the driver's mistake may have proven to be fortunate. Thus, it can be argued that reimbursement of a trade error should not be based on the idiosyncratic performance (which is not foreseeable) of one acceptable stock versus another over any particular period.

261. In these policies, the risk of trade errors often is unidirectional, since the investor benefits from any gains versus the intended action, until the error is corrected, while the manager covers any losses.

dustry practice rather than an analysis of legal liability.[262] Practices also vary among managers in different segments of the industry.[263] In addition, if an error is attributable to a broker, then the adviser will look to the broker to compensate its clients for any losses.

Because trade errors frequently are transactional, their economic effect on a client account also typically can easily be measured and the errors readily corrected. Once a manager has determined that it has a reimbursement obligation, the economic or "quantitative materiality" of the error's impact (on an account-by-account basis) versus the administrative expenses associated with correcting an error may be a factor considered by the manager in its reimbursement decision. In accordance with its trade error policies, the manager also will typically notify the affected account holders of material errors and of its reimbursement decision where it judges that there has been a quantitatively material impact on their accounts due to the trade error.

SEC enforcement actions against advisers in connection with trade errors generally have involved behavior that could be affected by conflicts of interest. Among other things, the actions have included instances in which the adviser failed to inform clients of the trade errors,[264] and engaged in improper affiliated transactions to either correct or hide the error to avoid reimbursing clients.[265] Enforcement actions also have been based, in part, on a manager's failure to follow its own internal procedures for the handling of trade errors.[266]

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262. Managers commonly carry insurance to cover legal liability from large trading errors.

263. In the hedge fund industry, for example, the general practice is not to compensate a fund for errors unless the manager is grossly negligent, although some managers may compensate investors based on a simple negligence standard. *See* Jennifer Banzaca, *How Should Hedge Fund Managers Approach the Identification, Prevention, Detection, Handling and Correction of Trade Errors?*, 6 HEDGE FUND L. REP. VOL 6, NO. 12,(Mar. 21, 2013).

264. *See, e.g.*, Jack Allen Pirrie, Advisers Act Release. No. 1284, 49 SEC Docket 721 (July 29, 1991) (the adviser failed to inform clients of trade errors and using clients' soft dollar credits to absorb a loss that otherwise would have been the responsibility of the adviser).

265. *See, e.g.*, M&I Inv. Mgmt Corp., Advisers Act Release. No. 1318, 51 SEC Docket 1375 (June 30, 1992) (the adviser was alleged to have engaged in improper affiliated transactions either to hide or correct a trade error).

266. *See, e.g.*, WAM Order, *supra* note 255.

Because of the potential for confusion, it is helpful to distinguish trading errors from investment model errors. Trading errors typically (though not always) occur after the manager has exercised investment discretion and made an investment decision.[267] They do not occur as part of the judgmental process associated with model development or the interpretation of model signals, or other research oriented activities. Instead, they frequently are the result of a miscommunication or operational mistakes not involving judgment. Importantly, the process outlined in trade error policies may be designed to prevent potential conflicts of interest between the manager and its clients that are not present with most model errors

Trading errors also normally (though not always) are transactional, relate to the purchase or sale of individual securities and can be more easily detected through pre-trade controls and subsequent reviews by the portfolio manager. Importantly, there is a very limited disclosure analysis (policies often require disclosure of the error if quantitatively material[268]) and the manager readily can determine which clients are affected by the error. Compliance staff also routinely plays a role in designing policies, reviewing exception reports,[269] and assuring that internal procedures are followed once trade errors are discovered.

While there are many different types of model errors, unlike trade errors, among other things they commonly are systematic (affecting many client accounts) rather than transac-

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267. As noted *supra* note 255, in some cases trading models may be part of the manager's investment strategy and designed to serve as a source of alpha. Depending on the context, these models also may be considered "research."

268. The standard often cited relates to quantitative materiality of an error in connection with net asset values reported for mutual funds that will require reprocessing of shareholder account values to compensate investors for losses. While there is no official SEC guidance, generally a pricing error is considered to be quantitatively material in the context of registered funds if it is more than one cent per share on a particular day of a fund's net asset value. Other types of errors are considered to be quantitatively material to individual investors, requiring compensation, if they are more than one half of one percent of the fund's net asset value. *See* Helm & Johnson, *supra* note 258, at 2 n.3 (citing Investment Company Institute, *Valuation and Liquidity Issues for Mutual Funds* (Feb. 1997)). The SEC has not established a specific method for calculating reimbursement amounts for compensable errors.

269. Trade errors also may be escalated and reviewed by a committee of the manager based on amount of the potential reimbursement obligation.

tional, presumed to be present and routinely discovered and corrected, typically do not produce outcomes that are different than the manager intends, may or may not materially affect performance (either positively or negatively), may persist undiscovered for a long period of time, may affect a broad portion of a portfolio in ways that are not easy to measure, may be mitigated by other controls; may involve some client accounts but not others, may not present a conflict of interest, and may not be material in light of the manager's disclosure. Moreover, when model errors are discovered, correction may not be as simple as reversing a trade made in error.

The next portion of this Article examines statements in the Orders in light of the distinction between trading errors and investment model errors, demonstrating the importance of the differences.

1. *Analysis of Investment Model Errors*

As noted earlier, statements in the Orders, and also separately by SEC staff in the News Release and other public comments, were critical of the Firm's failure either "to conduct any meaningful materiality analysis of the error's impact" or that the Firm performed only a "rudimentary and limited analyses to estimate the error's impact" and later, that the error, once discovered, was swept under the rug.[270] As illustrated below, many of these statements demonstrate the bias of approaching model errors from the familiar paradigm established for trade errors.

Model errors are discovered on a routine basis as part of a manager's model governance process. Potential errors in post-production models may come to the adviser's attention through a variety of channels, including feedback from portfolio managers, risk managers, audit or post-production validation efforts, among others. Unlike the simple process of detecting and remediating trade errors, even when a potential error is discovered, the source may not be clear, and not infrequently requires an investigation by the manager. As suggested earlier, if the error is not apparent, the manager might consider whether there is a design flaw, paradigm shift, data integrity problem or programming error.

270. *See* Firm Order, *supra* note 5, at 8.

With respect to programming errors, if the error can be corrected simply by conforming the programming of a model to previously approved versions, seemingly no analysis should be required (e.g., changing the scaling). It is plain, in fact, that the Model Error could have been corrected immediately by quietly changing the factor tables to reflect the intended exposure settings with no further analysis. Lost in the Orders is any mention of the Firm's change control process and the very important distinction between the analysis of an error undertaken for the purpose of making future decisions relating to a research model, versus the type of detailed forensic analysis of quantitative materiality that occurs in connection with trade errors.[271] In the latter case, the analysis is for reimbursement purposes and will have no effect on future decision-making.

As discussed later, within the industry it is acknowledged that it may be difficult, if not impossible, to measure the effect that an error has on performance, particularly with the subjective decision-making that occurs in all aspects of model development and application. Even with simplifying assumptions, the same kind of quantitative materiality analysis conducted in connection with trade errors can be extremely time consuming, costly, and subjective.[272] In the context of model errors, this type of analysis is not useful for the manager in connection with future investment decision-making on behalf of clients, or, in most instances, a prudent or practical application of an adviser's resources.[273] As Judge Richard Posner stated,

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271. A general reimbursement duty based on existence of an error is consistent with "strict liability," but is inapposite to the standard of reasonable care imposed on prudent fiduciaries. This standard also ignores the fact that duty advisers owe to their clients is to manage assets in a prudent fashion consistent with their disclosure, and not to produce error-free models—unless the manager has warranted to investors that its models are error free.

272. An assessment of the precise economic effect of the error in each case would not be possible in many cases and would be very time consuming. It is noteworthy that, as referenced in the Orders, it took a well-known economic consulting firm over six months to complete an assessment of the effect of the Model Error. *See* Firm Order, *supra* note 5, at 9.

273. Generally, cost is a factor that may be weighed in determining negligence. *See* Kenneth W. Simons, *Tort Negligence, Cost-Benefit Analysis, and Tradeoffs: A Closer Look at the Controversy,* 41 LOY. L.A. L. REV. 1171 (2008). Thus, even though an error may have been prevented in pre-production with greater resources and stricter controls, the manager only would be required in most cases to observe reasonable care in managing the portfolio.

"[r]ational people base their decisions on their expectations of the future rather than on their regrets about the past."[274] There is no benefit to investors of conducting a forensic analysis, such as that suggested by the Orders, except in the context of making payments for past actions. A more detailed analysis of the quantitative materiality of an error, similar to that undertaken on an account-by-account basis[275] for trading and valuation errors, is not practical with respect to model errors and should not be required unless the manager first determines that it has a reimbursement obligation.[276]

Any examination of an error that will affect future decision-making may require an entirely different kind of analysis than the forensic analysis suggested by the Orders. When model errors are discovered, quantitative managers may make decisions based on their intuitive understanding of the relative importance of an error stemming from their experience and mastery of the models. Or, they may undertake an initial impact analysis addressing the type of error, the significance of component models involved, and the number of portfolios or assets affected (e.g., the "rudimentary analysis" referred to in the Orders). The degree of formal analysis necessary may depend on the experience of the individuals involved. Experts, especially highly sophisticated professionals (such as those at the Firm and elsewhere), may base their decisions, in part, on their education and training, as well as years of practical experience researching and developing models, managing assets,

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274. RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 8 (Little Brown and Co., 4th ed. 1992).

275. An analysis also would vary based on the standards applicable to the relationship with a particular client, including the precise disclosure provided, individually negotiated contractual standards, and relevant state and federal laws that may be unique to that client.

276. The discovery of a model error by itself is not evidence that the manager has misled investors, violated any standard of care, managed a client's assets in a manner that was not intentional or prudent, or has a reimbursement obligation. Quantitative managers are among the best educated and most diligent in applying documented processes to manage investor assets. Although it is not possible to prevent all errors in models, in most cases fiduciaries are only required to exercise reasonable care in managing client portfolios. Thus, an analysis of an error should take into account both the model development process as well as secondary controls including, among others, the subjective decisions made by the portfolio manager and regular monitoring of client portfolios and model output to independently evaluate model results.

and their intuitive understanding of the models.[277] Based on this analysis, which may be informal and may or may not be readily understood by the SEC staff in all cases, the manager can make reasonable decisions about the level of organizational review to be undertaken, the speed with which an error is corrected, and the scope of corrective action and implementation of new controls.

Moreover, when errors in coding or other model errors are discovered, they generally are viewed in the context of the manager's ongoing awareness of the positions in portfolios and exposures that reflect the manager's intent—even with the possibility of errors. As observed throughout this Article, there is no perfect portfolio and a range of exposures and holdings normally are acceptable to a manager. Thus, while individual stocks and factor exposures may have been different without a particular error, it is likely that the portfolio actually constructed by the manager still embodies the manager's investment beliefs.

Following is a discussion of the complexity associated with analyzing errors in quantitative models based on the quantitative materiality standard used to analyze trade errors for reimbursement purposes, which appears to have the benchmark suggested by the SEC in the Orders.

2. *Time Periods May Be Subjective*

As an initial mater, determination of relevant time periods may be subjective. Unlike trade errors, it may not be clear when the precise event giving rise to any potential reimbursement obligation first occurred. In the Orders, the SEC (apparently based on the view that model errors are like trade errors) required the Firm to conduct damage calculations based on the time period in which the coding error first was introduced into the Firm Model, until it was corrected.[278] However, there may be multiple time periods to consider.

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277. Years prior to the events giving rise to the SEC's actions, Dr. Rosenberg was described as someone that could not be fooled by model results, and was constantly questioning the output of models based on his own expert understanding of risk. *See* PATTERSON, *supra* note 10.

278. Firm Order, *supra* note 5, at 9–10 (noting that Cornerstone's $216,806,864 damages estimate was based on "each month that a client account was impacted by the coding error," and requiring that respondents return that total amount in compensation to clients who were affected).

Since the reality is that model errors are impossible to entirely prevent, the event giving rise to a breach of a standard of care, or a disclosure violation, could be the time at which the error was introduced into the model; the period from which the manager was not able to effect the investment strategy disclosed to investors because of the error; the time at which the manager's post-implementation controls should have detected the error; the time it should have taken the manager to remedy the error in a prudent manner once discovered; the time at which latent errors became manifest; or some other event or time period. In addition, based on a disclosure standard under the Advisers Act, the appropriate period arguably may be the timing of a specific misstatement, or some other date in which the investor was presented with performance statistics or detailed information regarding holdings, and decided to remain invested in the strategy.

3. *Investment Models Are Both Systematic and Individualized*

If, upon discovering a model error, the manager decides that it has breached a duty to investors, the longer the period in which the breach of duty is present, the more complex and subjective the analysis of losses that might be attributable to the breach would become. Unlike a trade error in which the impact often is isolated to a single transaction, models do not make occasional or isolated mistakes. When errors are present in models, they might not affect model signals under many conditions. However, when they do influence model signals their impact may be repeated relentlessly over time, and have a widespread effect.

Also, as described earlier, there may be no single model used to manage client portfolios. Managers may employ many different versions of the same model, with different weightings, or apply unique factors that are individualized based on the industry segment, sector or country in which the strategy invests. Thus, an error may potentially affect many different dimensions of portfolios in ways that may be positive, negative, or neutral (or each of the foregoing, depending on the relevant time period).[279]

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279. Choosing an appropriate time period may also yield different results in calculating losses to investors. In the Firm Order, *supra* note 5, the consultant used monthly segments and offset gains and losses due to overexpo-

4. *Errors May Not Have an Effect on Performance*

As noted previously, even with an error, the actual holdings and exposures in a portfolio overall are likely to be consistent with a manager's intention. Because there are no perfect portfolios, a manager may tolerate a wide range of holdings that are consistent with the client's investment objective. Thus, for example, an error in a predictive model may have no effect on the outcome of a manager's stock selection process, since a security ranked by a model in the eight decile may be just as acceptable to the manager as one ranked in the tenth decile. An error, such as differing factor exposure, also may actually have had a positive effect on an adviser's strategy (i.e., it may have improved performance) and the manager may determine to retain the existing version of the model—even though it contains errors,[280] because the impact of an error may not be material[281] or may be negated entirely by other elements of the manager's investment process. Moreover, the effect of an error may be far murkier during periods in which market conditions deviate from historical norms that are used to develop the model. As discussed earlier, a manager may not know whether relative underperformance or overperformance is due to temporary irrational conditions, or the result of a design, data, or coding error.[282]

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sures to common factors only within that monthly segment. A different and equally reasonable measurement period (e.g., quarterly) may have yielded different results.

280. An error also may influence a manager's decision to acquire or sell a stock earlier than optimal, to retain a position too long, or to weight it differently.

281. As noted earlier, *see generally supra* Section I.A, hundreds of factors may be incorporated into models. Some factors may contribute less than a percentage point of the total weighting in the manager's investment process, and may not ultimately affect decisions made by the manager. Also, during a period in which an error is present in a model, its significance may vary based on both internal actions of the manager (e.g., modifications, enhancements and other interventions) and external events (e.g., market environment or the decline in the strength of signals due to the adoption of similar strategies by other managers) that are beyond the manager's control.

282. It also is worth noting that over short periods of time, a group of stocks affected by an error may perform worse than those that might have been chosen without the error, but those same stocks may have led to a greater return over a different period of time (e.g., defensive positions may be intended to minimize the impact of a down market that is the manager's investment horizon, or a full market cycle).

The analysis of the effect of an error may be further complicated by the fact that, among many other things, data from prior periods may not be readily available, losses may be offset by gains, and implementation of trades may have occurred differently. Finally, losses may be attributable to market factors other than those related to the error (e.g., an entire market segment or quantitative strategies in general declined during the period the error was undetected). As discussed previously, the fact that an error is present in a model does not mean that it resulted in the creation of portfolios that were inconsistent with the manager's investment philosophy.

5. *It May Be Difficult to Assess the Significance of Human Judgment*

The element of human judgment integral in the investment decision-making process also may make it difficult, if not impossible, to predict what might have happened but-for the error.[283] While quantitative investing is a much more disciplined approach to investing than fundamental investing, as emphasized earlier, within quantitative managers there are many different levels of subjective overlay applied in the portfolio management process and in model governance.

Although there are numerous gross decisions that an adviser makes regarding its models, other decisions are individualized at the portfolio level. Even if models worked to perfection, it is common for investment performance of one portfolio to vary from others relying on the same strategy, depending on a portfolio manager's expertise and judgment in calibrating the model or managing cash flows, interpreting signals, applying different models, choosing among substitution candidates, and the trade execution process, as well as client-imposed investment constraints. Differences in holdings and performance are common among portfolios managed using the same strategy—even with the same portfolio manager. Thus, the judgment of the portfolio manager and other controls may overshadow or eliminate the effect of a model error.

283. Chaos theory explains how small changes can produce significant effects—referred to as "path dependency."

C. *Decisions Relating to Model Error Correction Are Investment Decisions—Similar to Decisions Relating to Revisions in Traditional Research*

In the Orders, the SEC concludes that Dr. Rosenberg's decision not to share information relating to the Model Error may have delayed consideration of the error's effect and of the necessary corrective action that may have prevented investor harm.[284] Yet there is no evidence in the Orders that would support this position and (as discussed later) it appears that Dr. Rosenberg was the decision-maker in the Firm. Trade errors normally are treated with some urgency because of the potentially reimbursable losses that may be incurred by the adviser.[285] In addition, the SEC has stated that the failure to remedy and disclose trade errors promptly may violate Section 206(2) of the Advisers Act.[286] For this reason, many advisers have trade error policies that require errors to be addressed and disclosed promptly.[287] This same temporal standard has

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284. Rosenberg Order, *supra* note 6, at 5 ("In addition, Rosenberg's direction to delay fixing the error allowed it to remain uncorrected for several additional months. Because of his conduct, certain clients continued to sustain losses from an error that could have been but was not promptly corrected."); Firm Order, *supra* note 5, at 8 ("Because [the California Research Group] and [ARIM] failed to disclose the error, certain clients continued to sustain losses from an error that could have been but was not promptly corrected.").

285. The manner in which errors are defined or categorized in an adviser's policies may be important in determining how they may need to be addressed within the manager and what standards the manager will apply in determining any reimbursement obligation. For this reason, managers should ensure that escalation and other procedures addressing trade errors cannot unintentionally be read to apply to model errors. Whether or not separate policies are necessary for review of coding errors, if they are developed, care should be taken to assure that they are crafted in an appropriate manner—with the expectation that, even though they are operational controls, they will be reviewed by regulators and therefore should be followed.

286. Investment Advisers Act of 1940 § 206(2), 15 U.S.C. § 80b–6(2) (West 2016). *See, e.g.*, WAM Order, *supra* note 255; Jon N. Eisenberg, SEC Enforcement Actions Against Investment Advisers, Harvard Law School Forum on Corporate Governance and Financial Regulation (Nov. 7, 2015) ("The [SEC] staff expects that when an investment adviser discovers an error, it will act promptly to reimburse clients who were affected by the error.").

287. In addition, the SEC has stated that compliance policies must be designed to "promptly" address any securities law violations. *See* Compliance Programs of Investment Companies and Investment Advisers, Advisers Act

not been applied in connection with errors in research or the investment decision-making process, which do not lead to a regulatory violation.

As explained earlier, managers often trade only periodically and allow their portfolios to drift between periodic adjustments. Moreover, unlike trade errors, the correction of a model error may not be as simple as it might seem and may need to be vetted in accordance with the manager's change control processes. Thus, even if model errors are addressed promptly (in the sense that they are considered) after they are discovered, managers typically schedule the release of changes to a model. And, in many cases they may prudently choose not to correct a known error. Thus, the notion in the Orders that quantitative managers must promptly correct and disclose coding errors in their models[288] is both inconsistent with industry practice and not reflective of the manager's obligations as a fiduciary.

Any decision to correct an error in an investment model, whether a design flaw, data integrity problem, or coding error, will likely depend on the unique facts surrounding the error, which might include the importance of the model, whether the error significantly influences the manager's investment decisions, and the certainty that the result of correcting the error would be beneficial to clients over a period of time.[289] Decisions regarding the timing of an error correction may have an influence on positions and exposures of a portfolio and involve judgments that should be viewed as part of the manager's investment decision-making process, arguably no different than an enhancement to a model or update of traditional research.

Errors in models may have varying degrees of magnitude. Non-routine errors in significant or critical models that cause an observable result are likely to be detected and mitigated quickly. The level of criticality assigned to a particular error

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Release No. 2204 (Dec. 17, 2003) (adopting Rule 206(4)-7) [hereinafter "Compliance Release"].

288. *See* Rosenberg Order, *supra* note 6, at 5; Firm Order, *supra* note 5, at 8.

289. As suggested earlier, there may be a question about whether or not a model error was, in fact, an error. For example, the error may have existed in a version of the model that was back-tested and approved into production for use. *See generally* Section I.B.

may correlate, among other things, to the importance of the model, the number of portfolios affected, the weighting of the model or factor, and whether there are other controls in place that mitigate the error's effect. For example, an error that noticeably causes an index fund to stop tracking its benchmark, or errors in a short-term trading strategy, are likely to be treated with some immediacy and may not be subject the manager's normal change control protocols (sometimes referred to as "glass breaking"). However, the effect of minor model errors on the performance of investment models with longer-term investment horizons may not be clear and might require more deliberation and approvals prior to implementation.[290] Similarly, the effect of errors during abnormal market conditions may be uncertain.

It is common for software developers to consider the nature of the error (routine or non-routine), the likely effect that it may have had on a model's performance, and the complexity of making a correction in light of the interrelationship with other elements of a model.[291] Seemingly, for example, it

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290. As noted elsewhere, because the future is unknown, it is far less obvious how a particular error that resulted in different weightings of positions, might influence future performance.

291. Commonly, in software development, programming errors are prioritized in terms of their severity. While there are no standards, when a software error is discovered it may be categorized numerically or in terms such as "critical," "high," "low," "trivial" or "deferred." Among general factors considered by a developer in determining the priority for addressing an error might be the likelihood that the error ever would become manifest (e.g., rarely, if ever), the significance of the error (e.g., system crashes that make a program inoperable, or clearly adverse consequences) as well as the presence of other controls employed by the user that would mitigate or eliminate the effect of the error.

In the commercial software industry, a developer may delay correcting a known programming error under the following conditions: production deadlines may require that the developer correct only those problems above established severity levels prior to release of new or enhanced software, with the expectation that known problems will be corrected in a subsequent release; the error is not significant enough to warrant an immediate update or patch, and the problem already has been addressed in an upcoming release; the cost of making changes to the code necessary to fix a coding problem are too costly, will take too much time for the current release, or affect too many other areas of a program to be addressed on an ad hoc basis; a version of the software with the bug and corrections is being relied on by users, who have developed mitigating strategies, and the correction may introduce a "breaking change;" the coding error is in a portion of the program that will

would be a simple matter to correct an error that eliminates a mistake in previously approved versions of a model. However, as demonstrated by widely-publicized market events involving exchanges[292] and other market participants, modifications or corrections also can produce unintended effects if they are not fully considered at the time they are implemented.[293] Thus, some errors, whether significant or not significant, may be corrected quickly and easily. Other corrections may be more complex and necessitate time, expense, and consideration to implement, and may require the manager to make decisions about the allocation of resources.[294]

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be obsolete with an upcoming release; or the error is not a bug in the software, but reflects a misunderstanding due to miscommunication, design flaws, or some other flaw not related to programming. *See, e.g.*, *Software Bug*, WIKIPEDIA, http://en.wikipedia.org/wiki/Software_bug (last visited Apr. 8, 2017).

292. *See, e.g.*, NASDAQ Stock Market LLC et al., Exchange Act Release No. 69655, 106 SEC Docket 1774 (May 29, 2013). In this enforcement action against NASDAQ, and its affiliate, involving at the time the largest fine ever against an exchange, the SEC was critical of the hasty decision-making of NASDAQ with respect to computer glitches involving one of the largest IPOs in history. *Id.* at 3–13 The problems occurred when NASDAQ determined to open the secondary market for trading in Facebook "with the expectation that they had fixed the system limitation by removing a few lines of computer code. However, they did not understand the root cause of the problem[,]" which led to the violations charged by the SEC. *See* SEC Charges NASDAQ for Failures During Facebook IPO 2013-95, SEC Press Rel. (May 29, 2015).

293. One author estimated that twenty to fifty percent of all fixes to software errors may introduce new, unknown problems. *See* FREDERICK P. BROOKS, JR., THE MYTHICAL MAN-MONTH: ESSAYS ON SOFTWARE ENGINEERING (Addison-Wesley Longman, Inc. 1975). A knee jerk decision to correct an error immediately after discovery may not always be prudent. If models with errors are approved and released into production, the manager may need to back-test and validate the model without the error and determine whether the correction is implemented properly and whether it would be beneficial to its investors in the current and future market environments. In fact, a well-known spoof on a common song is:

> 99 little bugs in the code.
> 99 little bugs in the code.
> Take one down, patch it around.
> 127 little bugs in the code. . .

294. For example, a manager may decide that it is more beneficial to use its resources to implement an enhancement to a model than correct a coding error.

In addition, any decision by a manager to correct an error, or make an enhancement, particularly in a period in which the market is acting irrationally from the model's perspective, may involve the same subjectivity as that faced by traditional managers. While in many cases the benefit to a client of immediately correcting an error may be unproven—since the manager cannot foretell the future—there are likely to be costs associated with implementing any correction that causes a breaking change that would result in churning client portfolios. The costs, which include both transaction fees and price impact, may be significant and not warrant changes in a portfolio for the sake of "purity." Thus, depending on the facts, a manager may reasonably choose to correct the error at the time of periodic rebalancing or other events, such as the release of a new version of the model.

Ongoing monitoring of positions and the presence of other controls make it less likely that an error would affect performance, or that the manager would be acting unreasonably in not immediately correcting an error. Unless a model error makes a manager's disclosures inaccurate, causes it to operate in a manner that is inconsistent with its investment beliefs, violates specific restrictions, or presents any obvious harm to investors, quantitative managers acting in the best interest of their clients may prudently exercise discretion (as part of their investment decision-making process) regarding the necessity or timing of any error correction.

D. *A Manager's Obligation to Disclose Model Errors Is Contextual*

A related issue raised by the Orders, and one of the most difficult, is an adviser's obligation to disclose errors or other modifications to its models.[295] As explained earlier,[296] advisers are fiduciaries and have a duty both to refrain from fraudulent conduct and also to disclose material facts whenever the failure to do so would defraud or operate as a fraud or deceit upon any client. This duty is emphasized when there is a conflict of interest between the adviser and its client. Specific items of disclosure also are mandated under the Advisers Act and other portions of the securities laws. Decisions regarding

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295. *See* Rosenberg Order, *supra* note 6, at 4–5; Firm Order, *supra* note 5, at 8.

296. *See supra* Section II.A.

disclosure of facts not specifically mandated under the Advisers Act, or in guidance developed in case law and SEC actions, may be particularly difficult.

Although the SEC assessed damages based on the entirety of the period in which the error was present in the Firm Model, the Firm Order indicates that the SEC's action, at least partly, was about "conceal[ing] from investors a material error in its computer code in violation of the federal securities laws" and "provid[ing] . . . investors inaccurate information about the Model's performance and capabilities."[297] The Orders and News Release also described what the SEC, or its staff, believe were various misstatements and omissions regarding the effect of the error on performance and the Firm's internal controls. The Firm Order notes that:

> After discovery of the error in June 2009, the Respondents made material misrepresentations and omissions concerning the error to [the Firm's] . . . clients, including (i) omitting to disclose the error and its impact on client performance, (ii) attributing the Model's underperformance to market volatility rather than the error, and (iii) misrepresenting the Model's ability to control risks.[298]

Markedly, the Orders do not suggest that the Firm or Dr. Rosenberg had "conflicts of interest which might incline [them] . . . consciously *or unconsciously*—to render advice which was not disinterested."[299] Or, that disclosure of the error was necessary because their investors "must . . . be permitted to evaluate overlapping motivations, through appropriate disclosure, in deciding whether an adviser is serving 'two mas-

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297. Firm Order, *supra* note 5, at 2. There were no allegations that the Firm advertised hypothetical or back-test results, or that the actual performance results presented by the Firm were inaccurate or misleading. *See id.* Nor do the Orders suggest that the Firm had a conflict of interest, did not report their performance to investors correctly, mispriced assets, or misled investors about holdings or sector concentrations. *See id.* It is clear from the Orders that investors knew about the actual exposures in their portfolios as well as the performance in their accounts and were voicing their displeasure. *See* Rosenberg Order, *supra* note 6, at 2 ("Before and after the discovery of the error, [ARIM]'s clients were expressing dissatisfaction with their portfolios' underperformance.").

298. *Id.* at 6.

299. *See* SEC v. Capital Gains Research Bureau, Inc., 375 U.S. 180, 191–92 (1963).

ters' or only one, 'especially . . . if one of the masters happens to be economic self-interest.'"[300] The Orders also do not provide the full context in which the statements occurred, including the underperformance of many quantitative managers during the period of the Global Financial Crisis, and widespread investor concerns about the performance of quantitative managers.

This Article does not address whether the Model Error was material from a securities law perspective. However, some misconceptions about quantitative investing may be inferred from the SEC's allegations of disclosure violations. First, as explained more fully below, while the Orders suggest that managers control risk, it is more accurate to say that managers attempt or seek to control risk by employing risk models and optimizers. These models, which often are based on historic data and normal statistical correlations, may not perform well in extreme and unprecedented market conditions, such as the volatile conditions of the Global Financial Crisis, or when there is government intervention in the markets, that might lead to a crisis correlation among assets that otherwise are not highly correlated. Further, while managers often disclose specific risks, such as "complexity," they universally disclose the risk that their strategy (including risk models) may not be successful or perform as predicted.

Secondly, while a manager's lack of diligence in some cases may expose investors to a risk that is not otherwise prudent, there is no analysis in the Orders that would support the conclusion that the Model Error, and not the market itself, caused any underperformance, or that the Firm was not prudent in managing investor assets. As elsewhere, while the SEC may have possessed the relevant information, the Orders suffer from any discussion of whether or not the manager was able to implement its investment program as intended, and specifically whether it had any post-implementation controls intended to mitigate risk from model errors, or generally whether the manager's action was reasonable—the type of analysis that would be necessary to support (even if possible) the SEC's implication that a manager was not a prudent fiduci-

300. *Id.* at 196.

ary or was not able to effect the strategy disclosed to investors.[301]

1. *The Trade Error Template Is Not Suitable for Disclosure of Model Errors*

The earlier parts of this Article discussed the possible underfitting that occurs with respect to the application of a trade error standard to models that are used in the investment decision-making process. Statements in the Orders regarding disclosure of coding errors also appear to be based on the manner in which trading errors are addressed. Trade errors frequently are disclosed to clients when the manager determines that it has a reimbursement obligation, which presents a conflict of interest, and there is a quantitatively material effect on their portfolios, or the manager's policies otherwise call for disclosure. Moreover, the SEC has initiated enforcement actions in instances in which a manager has attempted to conceal trade errors from its clients or hide the information by altering records in order to avoid making reimbursement payments (scenarios that present a clear conflict of interest),[302] or failed to follow its trade error policies.[303]

Advisers normally receive fees that are a percentage of assets under management. These fees will automatically increase

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301. The Orders also indicate that the Firm disclosed that it had a model governance process, and that elements of the process were not followed. *See* Firm Order, *supra* note 5. It is difficult to judge the significance of this claim based on information provided in the Orders, but advisers should be careful not to misrepresent their controls. *See* First Capital Strategists, Advisers Act Release No. 1648, 65 SEC Docket 429 (Aug. 13, 1997) (adviser misrepresented the existence of controls to assure compliance with investment guidelines).

302. *See, e.g.*, Michael T. Jackson, *supra* note 258 (firm allegedly created false records to conceal a trade error and wrongly passed on the cost of the error to the investor).

303. Some trading error and investment policies address when clients must be notified of developments. There is no specific provision of the Advisers Act or any related rule that requires advisers to disclose model errors to clients. However, as noted in Section II.A.1.a, Section 206(2) of the Advisers Act, 15 U.S.C. § 80b–6, is read to require that advisers make full and fair disclosure of all material facts. In addition, a manager must act in a manner that is at least consistent both with its disclosure and its own policies regarding trade errors. As discussed later in Section III.D.2, coding standards and other internal protocols, however, have not been customarily disclosed to clients or considered part of an adviser's regulatory compliance policies.

or decrease based on the performance of a strategy. And, a manager may be terminated if a client is not satisfied with its performance. Thus, unlike trade error cases, in which a reimbursement obligation arguably creates a conflict of interest, a quantitative manager has a strong economic self-interest (that is closely aligned with the interests of the investor) in the development and application of its investment models. Neither quantitative managers (nor traditional managers) have regarded investment mistakes (versus trade errors) as compensable in most cases, both because they are not legally required to reimburse clients and it is not industry practice to make such reimbursements. For these reasons, when inevitable mistakes are discovered there is not likely to be a conflict of interest that compels disclosure under general fiduciary concepts.

Moreover, any analysis of a manager's disclosure obligations with respect to significance of model errors is likely to be much more complicated than trade errors. In the Orders, the SEC simply branded the Model Error as material from a disclosure perspective, noting that a theoretical investor would want to know that an error was present.[304] However, as discussed before, some model governance structures grade the models themselves and errors according to their significance. This type of identification and grading process for programming errors, however, may not be the same as that undertaken to determine the materiality of an error under the securities laws.[305]

In the context of the securities laws, the U.S. Supreme Court has indicated that there is no bright line test to determine materiality for disclosure purposes.[306] Instead, an assess-

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304. Rosenberg Order, *supra* note 6; Firm Order, *supra* note 5, at 2.

305. Because of the potential for confusion between the way the term "materiality" is used in industry parlance versus the more specific definition of that term for securities law purposes, managers should be cautious in labeling an error or model as "material."

306. A complete discussion of disclosure issues is beyond the scope of this Article. In 2016, the SEC issued an opinion that addressed many different disclosure issues that arise when a manager deviates from its disclosed strategy in a manner that introduces undisclosed risk. The facts in the SEC's opinion, which involved an undisclosed practice of using certain derivatives to enhance investment performance, differ substantially from those presented by model errors. Nevertheless, the SEC's Opinion is useful guidance in examining disclosure issues. *See* Riad Opinion, *supra* note 111 (discussing risk resulting from an undisclosed option strategy).

ment of whether a matter is material depends on context—the "total mix" of information—and also involves a balance between providing investors with significant information and not burying them "in an avalanche of trivial information."[307] "Something more than the mere existence of adverse . . . [information] is needed to satisfy that standard, but that something more is not limited to statistical significance and can come from the source, content, and context of the . . . [information]."[308]

An investment mistake or error cannot be pronounced as material in isolation. No manager is likely to assert that its models, research, or investment decisions are error-free. Errors in models that are not used, or have small weightings, or that are mitigated by other controls, will not have any significant effect on a manager's ability to implement its strategy. From a disclosure perspective, the materiality of the error must be viewed in the context of the manager's other controls, its tolerance for alternative outcomes, and the other disclosure provided to investors.[309]

2. *Advisers Should Not Be Compelled to Disclose Most Model Errors*

A manager's investment objectives and approach to investing and style usually are the key elements for many institutional investors in selecting a manager to provide exposure to

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307. *See, e.g.*, Matrixx Initiatives, Inc. v. Siracusano, 131 S. Ct. 1309, 1318 (2011) (concerning the need to disclose adverse event reports related to a pharmaceutical company's product); *see also* Basic, Inc. v. Levinson, 485 U.S. 224 (1988) (explaining that materiality "is satisfied when there is a 'substantial likelihood that the disclosure of the omitted fact would have been viewed by the reasonable investor as having significantly altered the "total mix" of information made available.'"); TSC Indus., Inc. v. Northway, Inc., 426 U.S. 438, 449 (1976) ("[T]here must be a substantial likelihood that the disclosure of the omitted fact would have been viewed by the reasonable investor as having significantly altered the 'total mix' of information made available.").

308. *See Matrixx Initiatives*, 131 S. Ct. at 1312.

309. The complexity of this analysis is highlighted by latent errors. As illustrated by the facts in the Orders, the symptoms associated with latent errors may not be apparent during one period, but may be visible during another. *See* Firm Order, *supra* note 5; Rosenberg Order, *supra* note 6. During periods when they do not affect a strategy, latent errors are evocative of the philosophical thought experiment: "If a tree falls in the forest, and no one is around to hear it, does it make a sound?"

a specific asset class.[310] Under Item 8 in Part 2 of the Form ADV, all advisers are required to disclose information regarding their investment strategies and material risks[311] present in implementing their strategy or pursuing their investment objectives. The instructions to Form ADV Part 2 require the adviser to use plain English and "avoid legal jargon or highly technical business terms unless you explain them or you believe that your clients will understand them."[312] More detailed information regarding elements of an adviser's strategy may be provided in institutional presentational materials, investor conferences, and one-on-one meetings.[313]

Managers also may offer varying degrees of disclosure about their processes and robustness of construction in presentations to specific institutional investors and during due

310. The News Release, *supra* note 13, naively indicates that managers must make a separate disclosure to investors whenever their models do not work as predicted. Rarely, however, do models ever work fully as predicted over a particular period of time, except in the sense that managers can predict the results of their decisions are not certain.

311. SEC Investment Adviser Brochure Form ADV, Part 2A, Item 8.B, https://www.sec.gov/about/forms/formadv-part2.pdf ("For each significant investment strategy or method of analysis you use, explain the material risks involved. If the method of analysis or strategy involves significant or unusual risks, discuss these risks in detail.") *See generally* Amendments to Form ADV, Advisers Act Release No. 3060 (July 28, 2010) (discussing disclosure of material risks), https://www.sec.gov/rules/final/2010/ia-3060.pdf. . It also is noteworthy that as part of the formal disclosure in their Form ADV Part 2, investment management agreements, and presentation materials, advisers also universally disclose that they are "seeking" an objective and that they may not be successful in implementing their strategy or reaching their investment objectives.

312. *Id.* ¶ 3. *But see* Riad Opinion, *supra* note 111 ("The plain English requirement is not license for registrants to omit material information about a principal strategy"). Regulators also have expressed concern that too much disclosure may overwhelm investors and not be useful. *See, e.g.*, Fiduciary Requirements for Disclosure in Participant-Directed Individual Account Plans, Department of Labor, 29 C.F.R. 2550 (Oct. 20, 2010). ("[T]he Department remains sensitive to the possibility that too much information may only serve to overwhelm, rather than inform, participants and beneficiaries.").

313. Some of the misleading disclosure cited by the SEC in the Orders appears to have occurred in private communications with institutional investors. In trade error cases, it generally is clear which clients are affected by the trade error. To the extent that misleading disclosure is provided in customized presentations, an individualized analysis—not an across the board assessment—of the effect of the disclosure should be required, particularly if the manager is held to a strict liability standard.

diligence reviews. Institutional investors (and their consultants), for example, may want to know more detail about the financial theory behind the models and how they extract value, as well as a firm's model governance. However, managers may be reluctant to describe in detail (and particularly in public documents like the Form ADV) specific elements of their strategies for fear that elements providing significant insights (i.e., their "secret sauce") might be replicated in the strategies used by other managers and lead to reduced opportunities for their clients.

While there are differences in the transparency and liquidity of investment vehicles, investors normally receive periodic information about holdings, segment, sector, and country exposures.[314] Performance attribution statistics and market commentary also often are provided by the manager to explain performance relative to any applicable benchmark and on an absolute basis. The statistics provided by advisers may show how over- or under-weighting a market sector, or factor, and the manager's security-specific selection process, contributed to relative performance versus its benchmark. Like managers themselves, however, sophisticated investors (who often have their own fiduciary responsibilities) monitor holdings, performance, attribution, and risk relative to target benchmarks established for the manager, including industry peer groups, and they often are guided by professional consultants.[315] Thus, even though an investor may not be aware of

314. Institutional investors using separate accounts and brokerage customers with accounts managed by an adviser may have daily access to reports of purchases, sales, and their total holdings from their custodians or brokers. Mutual funds also must disclose this information on a quarterly basis. *See generally* Shareholder Reports and Quarterly Portfolio Disclosure of Registered Investment Management Companies, Investment Company Act; Investment Company Reporting Modernization, Release Nos. 33-9776; 34-75002; IC-31610; (May 20, 2015) (proposing monthly reporting), https://www.sec.gov/rules/proposed/2015/33-9776.pdf. Many private fund investors also receive information periodically regarding portfolio holdings.

315. Retirement plans, foundations, endowments, and other institutional investors often hire professional consultants that are responsible for advising on asset allocation decisions; the selection of managers within an asset class; and monitoring the activities of the individual managers and measuring, over time, their risk-adjusted performance relative to a target benchmark and their peer group. Retail investors increasingly also have widespread access to analytical tools that show, among other things, the level of risk as-

the presence of an error in a model, in almost all circumstances they are made aware of the performance and other observable results of the adviser's investment process.[316]

a. Errors May Not Affect a Manager's Strategy or Investment Objectives

Core beliefs, reflected in a manager's disclosure regarding its strategy and investment objectives, generally are baked in. However, both quantitative and traditional managers regularly adjust their strategies based on new research, reviews of prior performance and market conditions—without notifying their investors prior to or following the changes.[317] In this sense, while the Orders cite examples in which the SEC believes that discovery of errors in a model should have been disclosed to investors, as explained before, in most instances the effect of the error will have been alleviated by the adviser's controls, including the adviser's ongoing monitoring, hard and soft position limits, periodic rebalancing, etc. The presence of any significant model error is not likely to go undetected by the manager, or sophisticated investors, or to cause

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sumed by the manager and how closely the manager's performance is tracking its benchmark over time.

If the manager's performance does not comport with client expectations (even if unrealistic) in most cases the manager may be terminated in a relatively short time frame. A model error may not be material to investors if the adviser is judged based on its relative performance, with or without errors. *Cf.* United States v. Litvak, 808 F.3d 160 (2d. Cir. 2015) (discussing misstatements by a dealer that were not relevant to the investment decision of bond buyers, who instead relied on their own valuation models to make purchase decisions).

316. *Compare* Riad Opinion, *supra* note 111, at 31–33 (in a different context, discussing whether investors should have been aware of a change in investment strategy based on disclosure of investments in quarterly reports).

317. During one-on-one meetings with institutional investors, quantitative managers may discuss new proprietary and academic research and express opinions regarding significant elements of their models and how they are contributing to performance. Elements of models may not be presented with granularity, or research and enhancements disclosed in detail, nor is there likely to be a discussion of the manner in which known model errors may have affected performance. For example, it would be unusual if investors were informed that the targeted exposure for inventory turnover should have been *X,* but the model error caused it to be *Y.* Or, in the majority of instances, that any precise factor exposure affected by an error or enhancement would have been relevant to an investor.

the manager to act in a manner that is inconsistent with the elements of the strategy or investment objective disclosed to investors.[318]

Except in the event that the manager has provided investors a formal model error disclosure policy,[319] the manager's general obligation to disclose errors (which could have been beneficial[320] or detrimental to the manager's performance) might be viewed in the same context as its obligation to disclose enhancements to its process or changes in the calibration of models.[321] Whether a change is made to a model in order to correct an error or to enhance a model, the change is not likely to cause the manager's prior disclosures regarding its investment strategy to be materially inaccurate.[322] In fact, as noted above, there is no evidence in the Orders that the Firm

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318. Similarly, a traditional manager may not disclose an error in a model it uses to monitor risk if reliance on the model is only a control process that is not disclosed to investors.

319. It is not clear whether most managers today have disclosure policies relating to model errors and whether those policies are provided to investors.

320. Managers typically make available actual past performance results, even though they may have discovered errors in their models, or may have made enhancements to their models over time. From a disclosure perspective, it is unlikely that managers would notify investors that *overperformance* was attributable to an error (e.g., without the error, it would not have performed as well; or conversely, there might be disclosure problems if it stated that it would have performed better without the error) or that they discovered an error that was mitigated by other controls.

321. As noted earlier, there is not agreement in the industry over whether many changes to a model are actually to correct errors or to enhance a model.

322. Although a mutual fund must pursue a strategy disclosed to investors, there is latitude in interpreting the requirement so long as there is not a material change in the investment strategy disclosed to investors. *See* Russ Wermers, *A Matter of Style: The Causes and Consequences of Style Drift in Institutional Portfolios* 3 (Dept. of Fin., Robert H. Smith Sch. of Bus., Univ. of Md.,Working Paper, 2012) (noting, "[w]e . . . find that the average mutual fund manager seems to pay little attention to controlling style drift . . . ."). The study also concluded that active managers that permitted style drift had better performance and were terminated by institutional investors at the same rate as those who controlled style drift. *Id.*; *see also* Louis K. C. Chan et al., *On Mutual Fund Investment Styles*, 15 REV. FIN. STUD. 1407 (2002); Keith C. Brown & W. V. Harlow, *Staying the Course: Performance Persistence and the Role of Investment Style Consistency in Professional Asset Management* (Dept. of Fin., McCombs Sch. of Bus., Univ. of Tx. Working Paper, 2005). But, the SEC has stated that:

ever intended to notify investors of the planned revisions to the Firm Model, that such notifications were common in the industry, or that disclosure of revisions or enhancements to models is compelled by the securities laws if they do not materially alter the manager's investment strategy and or otherwise inconsistent with a manager's other disclosures.

3. *Some Managers Have Modified Their Disclosure to Address the Possibility of Errors*

If the probable presence of errors in models alone were sufficient to make the manager's other disclosures misleading, then all quantitative managers would face potential enforcement actions by the SEC. Prior to the Orders, however, most managers had not felt it was necessary to address the possibility of coding or model-related errors in formal disclosures. As a result of the Orders, however, quantitative managers could be less likely to describe in detail processes that may have errors. Or, the Orders may cause them to add generic, defensive disclosure that addresses the risk of programming and other design errors.

Following the Orders, in fact, a number of quantitative managers amended their Forms ADV specifically to address the risk of model errors and what was industry practice prior

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> We as well as courts have long recognized that a "reasonable investor would have considered it important" to know about changes to portfolio composition that increase the risk exposure of a fund. Likewise, a "changed investment strategy" is material because a reasonable investor would view this information as bearing on whether the fund "would be able to achieve its stated investment objectives." And a reasonable investor would also "consider the true source of returns as important when making the decision to invest."

Riad Opinion, *supra* note 111; *see also Conflicts, Conflicts Everywhere—Remarks to the IA Watch 17th Annual IA Compliance Conference: The Full 360 View*, Speech by Julie M. Riewe, Co-Chief, Asset Management Unit, Division of Enforcement (Feb. 26, 2015) (indicating that one of the SEC Enforcement priorities for 2015 is "funds deviating from their investment guidelines or pursuing undisclosed strategies") ; UBS Willow Management L.L.C. & UBS Fund Advisor L.L.C., Advisers Act Release No. 4233, 2015 WL 6123024 (Oct. 19, 2015) (adviser allegedly failed to update offering materials when strategy changed); Gualario & Co., LLC & Ronald Gualario, Advisers Act Release No. 3186, 100 SEC Docket 3149 (Apr. 8, 2011) (adviser allegedly deviated radically from disclosed investment strategy).

to the Orders.[323] For example, some advisers provided new disclosure indicating that model development is a complex and error prone process and that they do not anticipate, in each case, undertaking an analysis of the effect of an error on performance; that in most cases they may determine not to carry out a complete analysis; and that they may not notify clients of model errors. They also have disclosed that once an error is discovered they may exercise discretion in correcting the error and may decide to delay correcting an error, or not to correct an error.[324] Others, who felt it was necessary to address the issue, have simply added disclosure that "models may have imperfections." Although this latter disclosure addresses the SEC's concerns set forth in the Orders, it is questionable whether such disclosure should be necessary for investors already sharply aware of the problems associated with software development evident in the news and use of technology in their day-to-day lives.[325]

In sum, the discovery of errors alone should not automatically require disclosure. The analysis is highly contextual and the issue must be examined in light of the totality of informa-

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323. The disclosure provided by individual quantitative advisers can be found on the Investment Adviser Public Disclosure page on the SEC's website: https://adviserinfo.sec.gov/.

324. Some fund groups that emphasize quantitative management also have disclosed in prospectuses the risk that their models and the data they receive may be flawed. While these managers have chosen to specifically address practices highlighted by the Orders, many advisers may believe that their current disclosure already encompasses the possibility of model errors. The prospectus of individual funds are easily searchable on the internet, and may also be found the SEC's website: https://www.sec.gov/edgar/searchedgar/mutualsearch.html.

325. Even if errors do not present legal or compliance risks, both traditional and quantitative managers may need to consider the reputational risk that may result if errors are disclosed to investors, and consider strategies to mitigate the effect of any misperceptions. If a manager determines that an error should be disclosed, it will need to consider *how* it would be disclosed. This would be a far more difficult exercise than simply disclosing a trade error that generally is limited to a few accounts. Disclosure of the model error, and the mitigating controls, would need to be simplified to a level understandable by the audience for the disclosure, but may necessitate far more detail about the manager's models and investment process than originally disclosed. Moreover, the manager may not be able to accurately quantify the effect of the error on past performance without extensive and lengthy analysis, or guarantee the effect of the correction or enhancement on future performance.

tion available. Thus, while in some cases disclosure of model errors may be necessary, in most cases it will not.

E. *Escalation Policies and Operational Controls*

1. *Escalation Policies Are Not "Compliance" Policies*

Based on a survey conducted shortly after the Orders were published, many asset managers at the time did not appear to have a formal model governance process that addressed model errors or that specifically required escalation of model errors.[326] In the Rosenberg Order, the SEC alleged that, once discovered, Dr. Rosenberg's failure to escalate the Model Error "as soon as he should have" violated the Advisers Act because the conduct was inconsistent with the Firm's internal escalation policies, which were based on a traditional corporate template.[327] In this instance, the SEC also appears to follow trade error precedent in which managers have been sanctioned for failing to observe their own internal procedures for addressing trade errors.

Normally, trade error policies identify who is to be notified when trade errors are discovered and have a level of escalation based on the potential reimbursement obligation of the adviser (often a calculation as simple as: *x minus y*). In the apparent absence of specific Firm policies covering model errors, the SEC—using the trade error analysis—anchored its findings of securities law violations on breaches of the Firm's general corporate ethics and escalation policies that were developed for internal purposes, were subjective, and were not designed to address model errors. General corporate escalation

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326. One survey taken at the time of the Orders indicated that a substantial percentage of quantitative advisers (41%) who participated in the survey did not have specific policies regarding the escalation and resolution of model errors. *See* Press Release, Capital Mkt. Risk Advisors & Int'l Ass'n of Fin. Eng'rs, CMRA & IAFE Survey Finds that Despite AXA Rosenberg/SEC Enf't Settlement 41.1% of Respondents do NOT Escalate Model Errors (Apr. 20, 2011) [hereinafter Survey]. The Survey also revealed that: 66.2% of the respondents had a model review policy, but only 49.4% had error disclosure policies. *Id.* It is not clear, however, whether those responding considered trade error policies in responding to the Survey. The Orders do not mention whether the Firm had a formal model risk governance structure, although the Firm was required as part of the settlement to retain a consultant to develop such a compliance structure. Firm Order, *supra* note 5, at 5.

327. Rosenberg Order, *supra* note 6, at 2.

policies that are based on the discovery of events potentially giving rise to regulatory or civil liability, or reputational harm, are not well tailored to address model errors and are not regulatory compliance policies. Prior to the Orders, for example, it was not clear that most managers ever would have considered model coding errors to be sources of civil liability or regulatory violations. In fact, the policies cited in the Orders were vague and required a great deal of subjective reasoning, and, based on the manager's assets under management, would have resulted in the constant escalation of even routine matters.[328] Nevertheless, in the Firm Order the SEC states that "[i]n not disclosing and escalating the error to senior management,[329] the Senior Official and other [California Research Group] . . . employees did not comply with these policies and procedures," which the SEC believed constituted a securities law violation.[330]

The discovery of model errors is no different analytically from the revelation of new information regarding any other mistake or potential enhancement relating to the investment decision-making process at quantitative managers. Many different types of mistakes and possible enhancements may be discussed within research groups, by portfolio managers, or with senior management. It is not likely that these internal discussions relating to the investment decision-making of a manager would be viewed by those involved in terms of their potential to create monetary or regulatory liability for a firm, or to cause

328. Escalation policies based on an assessment of potential financial impact on performance of coding or other model errors are not practical. An accurate determination of the effect of a coding error on performance would be highly subjective and may be impossible. For example, given the systematic nature of models, the financial impact standard (e.g., "actual loss of $25,000 or potential loss of $100,000") referenced in the Firm's general escalation policies would have required the escalation of even the most insignificant errors at most institutional manager who commonly have billions of dollars of assets under management. In the absence of very specific escalation policies covering a wide variety of actions—organizational culture, structure, and style of the individual managers may dictate which issues are escalated for review.

329. As noted earlier, arguably it appears that in his role as Chairman of the Firm, and as de facto research director, Dr. Rosenberg, himself, was the person to whom non-regulatory problems should have been escalated.

330. Firm Order, *supra* note 5, at 7.

reputational damage.[331] As explained later, internal research guidelines, programming documentation or controls, or other investment or operational guides are not typically (if at all) regarded as compliance policies, with the result that deviation from internal guidelines may in some cases result in internal discipline, but would not be considered to be a violation of a legal compliance requirement or regulatory breach by most managers.

a. Authority and Organizational Cultures Are Relevant

The Orders also foster the mistaken belief that some errors in models are events that should be escalated to the Chief Executive Officer or Chief Investment Officer of an adviser. However, each organization has its own management structure and culture (e.g., autocratic or collaborative), with its own chain of command. Moreover, individuals also have their own styles. Thus, while titles are badges of authority, they may not always reflect the reality of the way things operate within an organization. For this reason, the Head of Equity Investments or the Head of Research may exercise power and authority in their areas of responsibility beyond the Chief Executive Officer, or Chief Investment Officer, based both on delegated authority evident in their titles as well as their expertise.[332]

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331. Although investors universally are aware that software contains errors, there may be a misunderstanding about the operation of models and the secondary controls to mitigate the effect of errors. For this reason, model errors may present reputational risk, or "headline risk," that could harm the adviser's business (regardless of whether or not there are any legal or regulatory violations), if presented out of context. The Federal Reserve System's *Commercial Bank Examination Manual* defines "reputational risk" as "the potential that negative publicity regarding an institution's business practices, *whether true or not*, will cause a decline in the customer base, costly litigation, or revenue reductions." *See* FED. RESERVE SYS., COMMERCIAL BANK EXAMINATION MANUAL 6.5 (1994) (emphasis added).

332. "Power" generally is defined as the ability to coerce or influence people, while "authority" is the formal power delegated to the holder of a position (e.g., the right to reward or punish). Numerous studies of organizational behavior discuss the motivations of corporate managers. *See, e.g.*, JOHN KENNETH GALBRAITH, THE ANATOMY OF POWER (1985). Within businesses, particularly smaller organizations, titles may not define spheres of influence. For example, within some investment advisers a star portfolio manager may have influence beyond his or her title. The issues raised in the Orders are particularly complex because the Rosenberg Order reveals that Dr. Rosenberg had both "positional authority" by virtue of his role as Chairman of the

Quantitative research groups in larger advisers may make enhancements and resolve errors in their models without seeking approval from Chief Executive Officers—no differently than a portfolio manager or the head of fixed income investments may act within their delegated authority.[333] By the same token, committees formed specifically to review errors or changes may or may not include the Chief Executive Officer or the Chief Investment Officer.

In his capacity as de facto head of the California Research Group, Dr. Rosenberg made the decision not to immediately correct the error.[334] Although this decision was made by the California Research Group, the Rosenberg Order strongly implies that Dr. Rosenberg was the individual within the larger organization that set the tone for the Firm, with respect to models and research, and who would have made any subsequent decisions regarding the effect of the error or the timing of any correction even if the matter were escalated.[335] While he did not hold the title of Global Chief Investment Officer or Global Chief Executive Officer, the SEC explains in the Rosen-

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Board and actual or de facto Head of Research for the Firm; as well as "expert power" based on his experience and mastery of the Firm Model. *See* Rosenberg Order, *supra* note 6, at 3.

333. While it is not known how things worked within the Firm, in other organizations, individuals, or committees may be formally or informally empowered to make decisions within a certain range of responsibility. Depending on the issue, from an organizational perspective, leaders and decision-makers may view the sharing of information with those who have similar levels of authority, who are less experienced (and even those with similar experience), or who are not capable of offering significant insight, as unnecessary "validation." For example, if the research director views an issue solely as limited to the design and operation of models, and has the relevant scope of authority to make a particular decision (and assuming no clear protocol to the contrary), he or she may not seek the opinion of the compliance staff, legal department, or others not skilled in model development.

334. According to one article:

> In June 2009 [shortly after the error was discovered] . . . [t]he chief investment officer, who was responsible for implementing a portfolio strategy based on the model's outputs, was also notified [of the error]. However, Barr [Dr. Rosenberg] made the decision not to inform the group CEO, the head of compliance, or the board of directors. Instead, he proposed that his team wait and correct the error during the next round of code updates that were scheduled to take place a few months later.

Larcker & Tayan, *supra* note 166, at 3.

335. Rosenberg Order, *supra* note 6, at 2.

berg Order that, among other things, he was Chairman of the Board of the Firm, which he co-founded. In fact, both the Firm and the California Research Group (or the BRRC—Barr Rosenberg Research Center, Inc.) still bore his name. The Rosenberg Order also reveals that he was the "leading quantitative expert" and "intellectual leader" of the organization, and "exercised significant authority throughout the Firm by virtue of his significant ownership stake, his 'founder' status, and his 'mastery of the Model.'"[336] Thus, it appears that Dr. Rosenberg may have had both the authority and power to make decisions regarding the Model Error.[337] In the absence of express policies designed to address model errors, it is not clear based on the facts presented in the Orders that he acted improperly by not advising others of the Model Error.

2. *Operational Controls and Investment Policies Are Not Regulatory Compliance Policies*

Broad statements in the Orders and New Release regarding compliance functions, which were noted by the industry and discussed in conferences, seem largely based on trade error precedent as well as the misapplication of the term "compliance" as it is used in model development compared to the way the same term is used under the securities laws. Among other things, the SEC indicated that the Firm violated Section 206(4) and Rule 206(4)-7 of the Adviser's Act[338] by failing to prevent the coding error. As noted earlier, the Firm Order states that:

> "[b]ecause . . . [the Firm's] *compliance program* did not sufficiently identify and mitigate the risks associated with the Model's development, testing, and change

336. *Id.* at 3. Despite the presence of formal policies and titles within quantitative investment managers, there also may be an internal culture of deference to those individuals with the greatest knowledge or experience regarding a model (e.g., the Director of Research rather than the Chief Investment Officer). *See* Larcker & Tayan, *supra* note 166 (providing significant additional detail about the inner workings of the Firm).

337. However, there is no discussion in the Rosenberg Order whether Dr. Rosenberg had made similar types of decisions in the past. *See* Rosenberg Order, *supra* note 6.

338. 17 C.F.R. § 275.206(4) (2017).

> control procedures, the coding error operated undetected for more than two years."[339]

In addition, in the News Release, the SEC stated:

> "[t]he coding process for the model represented a serious *compliance risk* for . . . [the Firm] and its clients because accurate coding is required for the model to function properly and in the manner represented to clients."[340]

These statements have further blurred the line between business and operational controls and regulatory compliance policies, as well as the role of compliance officers.[341] Compliance departments often use software designed to process proposed trade allocations that will alert the compliance staff to whether there are investment restrictions associated with a

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339. Firm Order, *supra* note 5, at 9 (emphasis added).

340. Press Release, SEC, SEC Charges AXA Rosenberg Entities for Concealing Error in Quantitative Investment Model (Feb. 3, 2011) (emphasis added), https://www.sec.gov/news/press/2011/2011-37.htm. Similarly, based on the false notion that a reasonable manager may prevent all model errors, and ignoring post-implementation controls, the Firm Order also states:

> BRRC was not subject to fundamental compliance procedures and controls. BRRC violated Rule 206(4)-7 by failing to adopt and implement policies and procedures reasonably designed to ensure that it did not make false and misleading statements and/or omissions to clients and investors, including failing to ensure that the Model performed as represented, in violation of the antifraud provisions in the Advisers Act. BRRC claimed that its Model would, among other things, assess common factor risks. Yet, BRRC did not have reasonable procedures in place to ensure that the Model would assess those risk factors as intended.

Firm Order, *supra* note 5, at 9.

341. Compare Robo-Adviser Guidance, *supra* note 149, in which the SEC Staff suggested that Chief Compliance Officers enhance compliance procedures for robo-advisers that would ensure that "code is adequately tested before, and periodically after, it is integrated into the robo-advisers' platform; the code performs as represented; and any modifications to the code would not adversely affect client accounts." *But see* Dechert OnPoint SEC Staff Issues Guidance Update and Investor Bulletin on "Robo-Advisers" (Mar. 2017) (a law firm client bulletin discussing the Robo-Adviser Guidance and noting "the Staff's suggestion differs from the traditional treatment of the provision of investment advice not as a compliance function but rather a proper subject of management supervision."). Portions of the Robo-Adviser Guidance also do not appear to reflect the reality of model development and the routine nature of enhancements.

portfolio that would prohibit the proposed trade. This software is coded to assure adherence to client restrictions, legal limitations, or other guidelines that are designed to prevent mistakes that would cause legal violations or that fall within the guidance for trade errors. If the trade would violate these limitations then it is rejected. The same software will likely generate exception reports that are reviewed by compliance staff in order to identify problems that may have resulted from the prior day's trading.[342] This type of software requires the accurate coding both of portfolio restrictions as well as any relevant security characteristics, but the software is vastly different in function than an investment model.

Read broadly, the statements by the SEC's staff in the News Release would encompass a wide range of errors that may occur in the investment management process,[343] and may be interpreted as greatly expanding the investment industry's understanding of the regulatory compliance obligations of advisers and their compliance personnel.[344] It is doubtful, for example, that any oversight by personnel equipped with an intimate knowledge of the securities laws would have prevented the Model Error. However, as discussed below, the Orders suggest that the SEC has mistakenly shifted the securities compliance obligation of advisers well beyond regulatory standards, client restrictions, or assuring that disclosure is accurate, and

342. *See* Western Asset Mgmt. Co., Advisers Act Release No. 3762, 2014 WL 281316 (Jan. 27, 2014). Larger advisers may have compliance groups that establish investment guidelines on the front end—at the time an account is established—and also code investments to prevent violations of investor or legal constraints. These pre-trade compliance models may flag potential problems, including transactions in prohibited securities or concentration risks in an issuer, sector, or credit quality tier. Back-office systems often provide automatic feeds of compliance tests and daily trades. The SEC noted in the 28(e) Interpretive Release, *supra* note 249, at 42, that software models used for the purpose of "creating trade parameters for compliance with regulatory requirements, prospectus disclosure, or investment objectives" were not "research" for purposes of the Section 28(e).

343. For example, instead of the "coding error" in the statement above, it would be easy to substitute "design error" or "data error" or many other investment-related errors at both traditional and quantitative advisers.

344. The SEC staff also focuses on both enterprise and business line risk. *See, e.g.*, SEC Office of Compliance Inspections and Examinations, National Exam Program, Examination Program for 2013 (indicating that the Staff will continue to focus enterprise and business line risk), https://www.sec.gov/about/offices/ocie/national-examination-program-priorities-2013.pdf.

is using the securities laws to mandate that advisers have controls to prevent any mistakes that may occur in connection with the investment decision-making—a business function.[345]

3. *Compliance Officers Are Not Risk Managers or "Supervisors"*

The term "compliance" generally is used in model governance to mean following operational protocols. A manager also may have policies to assure compliance with OSHA, or labor laws, but these policies are not regulatory compliance policies for purposes of the Advisers Act.[346] It is very clear that the policies mandated by Rule 206(4)-7 only are intended to assure compliance with the federal securities laws.[347] Processes that relate to the integrity of coding of investment models, just like OSHA policies, are not considered by the industry to be compliance controls mandated by Rule 206(4)-7.[348]

No compliance officer was charged by the SEC in the Orders, and the SEC has not offered any guidance in this context about the role of compliance officers in the investment management process. The Compliance Release indicates that compliance officers should be familiar with the securities laws and develop procedures to assure that a manager operates in a manner that is consistent with the federal securities laws.[349] It

345. *Cf.* OCC Bulletin, *supra* note 71 ("Compliance with [model governance] policies is an obligation of model owners and risk-control staff, and there should be specific processes in place to ensure that these roles are being carried out effectively and in line with policy.").

346. Under Rule 204-2(a)(17)(i) of the Adviser's Act, advisers must keep records of "policies and procedures formulated pursuant to §275.206(4)-7(a)." 17 C.F.R. § 275.204(a)(17).

347. Compliance officers also are required under Rule 204-2(a) of the Advisers Act to conduct annual compliance risk assessments.

348. The Compliance Release, *supra* note 287 enumerates specific types of violations that the SEC believes at a minimum must be addressed by compliance policies—and states that violations should be "promptly addressed." The broadest categories of possible areas of violations identified in the Compliance Release incorporate those related to:

> Portfolio management processes, including allocation of investment opportunities among clients and consistency of portfolios with clients' investment objectives, disclosures by the adviser, and applicable regulatory restrictions . . . .

349. In addition to the Advisers Act and Investment Company Act of 1940, compliance personnel also may need to be familiar with Office of Foreign Assets Control (OFAC) limits on investments and with trading restrictions under the Exchange Act—and particularly short sale restrictions—that

also states that an adviser should "identify conflicts and other compliance factors creating risk exposure for the firm and its clients in light of the firm's operations, and then craft policies and procedures to address those risks."[350] The risks referenced in the Compliance Release generally refer to those that will result in tangible securities regulatory violations.[351]

The SEC has sown confusion among compliance officers as it increasingly has sought to make them more responsible for functions relating to operational integrity claiming that it can affect disclosure.[352] The design and implementation of model governance procedures relating to investment models is a business and investment management function that can be

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would enable them to impose pre-trade limits. Among firms with trading strategies, there may be a greater role for compliance personnel in reviewing investment models based on the numerous rules and restrictions associated with trading activities imposed under the Exchange Act and by the rules of markets. In these cases, it may make more sense to incorporate compliance personnel in development of investment models to determine whether a particular trading model will violate the law. Similarly, some sources of information may present insider trading, outsider trading, or market integrity concerns that may benefit from compliance review. Compliance Officers now must be concerned with liquidity risk. *See* Liquidity Risk Management Programs, 7 C.F.R. § 270.22e–4 (2016) (requiring registered mutual funds to assess, manage, and periodically review their liquidity risk, based on specified factors).

350. *See also* OFFICE OF THE COMPTROLLER OF CURRENCY, COMPTROLLER'S HANDBOOK, ASSET MANAGEMENT, CONFLICTS OF INTEREST (2015) (discussing in detail various conflicts faced by banks acting as asset managers); FINRA, REPORT ON CONFLICTS OF INTEREST (2013).

351. Advisers Act Rule 206(4)-7(b) requires that an adviser's compliance procedures be reviewed not less frequently than annually. 17 C.F.R. § 275.206(4)-7(b). In various statements, the SEC's staff has encouraged compliance personnel to develop a risk matrix. *See, e.g.*, SEC, 2006 CCOutreach Regional Seminars Investment Adviser Case Study Discussion Guide, https://www.sec.gov/info/cco/cco_matrixguide.pdf.

352. To assure independence of the risk management function, the Chief Compliance Officers (CCOs) at some firms may participate in periodic audits of account-specific guidelines and identify potential violations, such as owning prohibited securities or impermissible concentration in an issuer, sector, or credit quality tier. They also may participate in meetings regarding model governance, risk management reviews of performance that are conducted relative to a benchmark over time, adherence to investment guidelines and GIPS standards, compliance violations, and any potential style drift or investment process deviation. The SEC has also taken steps to require registered funds to enhance "fund level" controls to identify and address risks related to the composition of portfolios.

highly sophisticated. Unlike specific rules or client investment restrictions, there is no SEC guidance on strategies that must be followed, research methods that must be observed, factors that must be considered, or any other elements of the investment process that are mandatory—as long as the practices observed are consistent with what is disclosed.[353]

While it is reasonable for a compliance department to have limited ownership of portions of a model governance or risk management structure, the role of compliance departments should not be extended to operational or investment risk management functions. The creation of controls over the development and operation of investment models is beyond the core competency of most legal and compliance departments.[354] It is unrealistic to expect that compliance officers

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353. *See* Office of Compliance, Inspections and Examinations, SEC, Forensic Measures for Funds and Advisers (Nov. 14, 2007) (unpublished handout distribued at CCOutreach National Seminar 2007), https://www.sec.gov/info/cco/forensictesting.pdf (focusing on compliance review of procedures for valuation, trade allocation, performance calculation, and traditional compliance functions, and not software development).

354. FINRA has recognized that development and supervision of trading systems is a business function and proposed a separate registration and testing requirement for employees of broker-dealers who supervise algorithmic trading. *See* FINRA, Regulatory Notice on Registration of Associated Persons Who Develop Algorithmic Trading Strategies (Mar. 2015), http://www.finra.org/sites/default/files/notice_doc_file_ref/Notice_Regulatory_15-06.pdf. The FINRA proposal would apply to the business person within a broker-dealer primarily responsible for the design, development, or significant modification of an algorithmic trading strategy and is intended to assure that they are aware of FINRA regulations and other securities laws, and not to assure the strategy is profitable or operates perfectly. *See id.* If the broker-dealer uses third parties to develop trading algorithms, then the associated person responsible for directing development would need to be registered. *See id.* There is no suggestion, however, that the compliance department must be knowledgeable of non-legal or regulatory subject matter, such as programming, or that they must possess the skills necessary to design and implement strategies.

Moreover, the level of policy interest of regulators in the operation of programs and systems in the context of high frequency trading, or firms that rely heavily on derivatives, may be distinctly different than their interest in investment processes employed by advisers in long-term equity strategies. In the former case, heightened regulatory attention may be predicated on a policy interest in protecting the national securities markets by preventing large market movements or specific violations of the securities laws (such as manipulation of the market). The same level of Congressional policy interest under the securities laws is not found in assuring the absolute investment

working for quantitative managers will have backgrounds in econometrics, computational finance, applied mathematics, computer science, or financial engineering, as well as a detailed knowledge of portfolio management that would be necessary to prevent a host of errors that can occur in model design or implementation.[355] Nor will they likely be in a position to credibly challenge the decisions of experts employed by an adviser.[356] Thus, they generally are not expected to develop protocols for programming, or to question the sample size, bias, math, or any of a number of processes that result in the formulation of models, or the judgment of those who are employed to develop and apply the models.[357] By the same token,

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performance received by participants in an individual investment strategy, provided there is full disclosure. As an illustration, there might be less of a broad public policy interest in the investment performance of an equity manager with a long-term investment strategy, whose actions affect only its clients, than a trading firm or dealer whose actions may not only affect its own clients but also violate the law by, among other things, artificially influencing the price of stocks in the market; or whose failure may impact the national clearance and settlement system.

355. Both securities compliance officers and legal officers are an integral part of the risk framework within their specialties. For example, lawyers may review many vendor agreements. Both lawyers and compliance officers also may have oversight of legal risks and compliance risks, respectively, and may be part of new product reviews, updating compliance policies to reflect new regulation, providing oversight of disputes, etc. However, securities compliance officers should not be responsible for designing or enforcing controls over investment model programming, or many other investment policies that do not have regulatory implications. *See also* FINRA, Regulatory Notice on Equity Trading Initiatives: Supervision and Control Practices for Algorithmic Trading Strategies (Mar. 2015), https://www.finra.org/sites/default/files /notice_doc_file_ref/Notice_Regulatory_15-09.pdf.

356. *See, e.g.*, Carlo V. di Florio, Director, Office of Compliance Inspections and Examinations, The Role of Compliance and Ethics in Risk Management, Speech at the NSCP National Meeting (Oct. 17, 2011) [hereinafter Di Florio Speech], https://www.sec.gov/news/speech/2011/spch101711 cvd.htm. Securities compliance officers may "own" limited portions of models in the context of a risk management or model governance framework, and assure some independence in the oversight process, but their role should be tailored. Similarly, legal departments may own, or advise on, particular elements of the manager's process.

357. It is doubtful that most securities compliance officers read the same journals as quantitative or research analysts. To illustrate this point, a recent review of the University of Chicago's *Journal of Econometrics* showed that the most downloaded articles over one ninety day period in 2016 were Jungyoon Lee & Peter M. Robinson, *Series Estimation Under Cross-Sectional Dependence*,

it is not likely that a compliance officer would be able to question the formulas drawn by Ph.Ds. on white boards at research group meetings, or that their presence at these meetings in most cases would be productive or welcome. Moreover, the task of overseeing model governance is even more difficult, if not impossible, if models are developed by unregistered foreign affiliates or third parties.

As the Comptroller of the Currency noted in a recent statement on model governance: "[b]usiness units are generally responsible for the model risk associated with their business strategies."[358] Statements in the Orders and News Release which intimate that compliance officers should be involved in designing systems to prevent a host of different types of investment errors also would make them responsible for a business function that could cause them to be "supervisors" and subject them to liability.[359] In fact, as previously mentioned, decisions

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190 J. ECONOMETRICS 1 (2016); Jungyoon Lee & Peter M. Robinson, *Panel Nonparametric Regression with Fixed Effects*, 188 J. ECONOMETRICS 346 (2015); and Frank Kleibergen & Zhaoguo Zhan, *Unexplained Factors and Their Effects on Second Pass R-Squared's*, 189 J. ECONOMETRICS 101 (2015).

358. *See* OCC Bulletin, *supra* note 71; *see also* Di Florio Speech, *supra* note 356 ("The business is the first line of defense responsible for taking, managing and supervising risk effectively and in accordance with the risk appetite and tolerances set by the board and senior management of the whole organization.")

359. *Cf.* Frequently Asked Questions About Liability of Compliance and Legal Personnel at Broker-Dealers Under Sections 15(b)(4) and 15(b)(6) of the Exchange Act, SEC (Sept. 30, 2013), https://www.sec. gov/divisions/marketreg/faq-cco-supervision-093013.htm. The FAQ suggests that compliance officers may be considered "supervisors" if they are given or assume supervisory authority or responsibility for particular business activities or situations, or if the firm's policies and procedures or other documents identify them as responsible for supervising or overseeing one or more business persons or activities. While this FAQ is geared towards compliance officers at broker-dealers, it is widely believed to apply to compliance officers at advisers as well. *But see* Robo-Adviser Guidance, *supra* note 149, regarding compliance policies and the role of the CCO:

> Thus, in addition to adopting and implementing written policies and procedures that address issues relevant to traditional investment advisers, robo-advisers should consider whether to adopt and implement written [compliance] policies and procedures that address areas such as: The development, testing, and backtesting of the algorithmic code and the postimplementation monitoring of its performance (e.g., to ensure that the code is adequately tested before, and periodically after, it is integrated into the robo-advisers'

regarding the impact of an error, how any correction will affect future performance, and the timing of any correction are ultimately investment management decisions. Thus, while compliance officers might be familiar with model governance concepts[360] and may play an advisory role (with perhaps a seat at the table),[361] or own aspects of the manager's operation that relate to regulatory compliance, they should not normally take responsibility for the development and operation of systems, make judgments regarding the integrity of data,[362] decide whether or not to correct mistakes or errors in software, or undertake other portfolio management functions.

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platform; the code performs as represented; and any modifications to the code would not adversely affect client accounts); . . .

360. *See supra* note 71, providing references to regulatory guidance on model governance.

361. For example, they may need to attend meetings to assure that the Form ADV and pitch books accurately describe the manager's strategy and control processes. *But see* Robo-Adviser Guidance, *supra* note 149, stating that CCOs might develop compliance policies relating to, among other things: "[t]he disclosure to clients of changes to the algorithmic code that may materially affect their portfolios" and "[t]he appropriate oversight of any third party that develops, owns, or manages the algorithmic code or software modules utilized by the robo-adviser . . . ." (Citations omitted).

362. Data sources have been a priority of the SEC's exam staff. In some cases, compliance departments may need to assure themselves that data, whether purchased from third parties or gathered from surveys, is publicly available and does not present any insider trading concerns. *See supra* note 106; *see also* JACK JRADA ET AL., *Developments in Banking and Financial Law: 2013*, 32 REV. BANK AND FIN. L. 221 (2013) (discussing measures to prevent the receipt of insider information, including contractual provisions in data vendor agreements.) To mitigate regulatory concerns, even if unfounded, managers in some cases conduct due diligence of data vendors and get representations from vendors, or other data sources, that no duties to an issuer have been breached and that the information is not non-public. Advisers are required under section 204A of the Advisers Act to have controls to prevent the use of material non-public information. 17 C.F.R. § 275.204A-1 (2016). The controls must be crafted to address the nature of the adviser's business and the SEC has emphasized that an adviser cannot rely on its employees in possession of the information to self-evaluate information that they receive. *See* Marwood Group Research, LLC, Advisers Act Release No. 4279, 2015 WL 7450392 (Nov. 24, 2015) (involving information acquired from government employees).

F. *Policy Implications of the SEC's Analysis*

Cross-validation is a technique used in statistics to test a model against data that was not used in the original training set. The analysis in the SEC Orders reflects the underfitting associated with applying the trade error regime to coding errors in investment models. The SEC's analysis in the Orders would fail attempts at cross-validation because, among other things, it does not work in the context of other types of model errors, the investment decision-making process of traditional managers, or development and use of traditional third-party research or investment models.

1. *Quantitative Managers Versus Traditional Managers*

The legal analysis in the Orders is disturbing because it delves deeply into the investment decision-making process of an investment adviser. Following the Firm Order, concerns were voiced at conferences and in other forums within the quantitative community about a double standard applied by the SEC to quantitative versus traditional managers. Quantitative managers contrasted their own highly sophisticated and generally transparent investment decision-making processes with the more freewheeling approach undertaken by some traditional managers. Examples of the apparent double standard were presented in industry conferences and private communications.[363] While the response to the Firm Order in the quantitative community was mostly lighthearted, there also was a feeling that it was unlikely that the SEC ever would have questioned an investment decision by a well-known traditional manager, comparable to Dr. Rosenberg, to tilt towards equities rather than bonds, growth rather than value, or India rather than China.

There is no legal basis for the SEC to suggest that quantitative managers have a higher standard of care (e.g., strict liability) with respect to investment mistakes than traditional managers.[364] Quantitative managers, like traditional manag-

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363. Illustrations of the seeming hypocrisy abounded. Helpful suggestions from the quantitative community included requiring traditional managers to disclose news that was overlooked, family emergencies, health issues, SAT scores, etc., all of which also may have been meaningful to some investors.

364. Related to this paradox is the SEC's willingness to intrude on the decision-making process of quantitative managers in ways that would not be

ers, have wide latitude under traditional fiduciary principles when they exercise reasonable care and make decisions in good faith that are not inconsistent with their disclosure. Investment professionals at both quantitative and traditional advisers also may have internal disagreements about investment management decisions. Moreover, although some types of model errors are more transparent and easy to detect,[365] they should not be viewed differently by the SEC than imperfections in the research conducted by traditional managers, or the opaque mistakes reflected in the subjective investment decision-making of those managers. Although quantitative mod-

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applied to traditional managers. The examination of quantitative managers by the SEC without cause has been the subject of concern within the industry because of the intrusive nature of information requests that may force advisers to reveal sensitive, confidential information about their "secret sauce." *See, e.g.*, Andrew Ramonas & Richard Hill, *Dodd-Frank Redo Would Limit SEC Access to Source Code*, SECURITIES LAW DAILY (Apr. 13, 2017) (discussing legislative efforts to require the SEC to obtain subpoenas to examine source code), https://www.google.com/amp/s/ www.bna.com/doddfrank-redo-limit-n579 82086612/%3Famp%3Dtrue. These requests are analogous to the SEC's exam staff interviewing traditional portfolio managers about the proprietary aspects of their investment process.

Congress was aware that managers would not wish to disclose detailed elements of their investment strategies. Section 204(b)(10) of the Advisers Act provides an exemption from public disclosure of information gathered by the SEC from advisers that is "proprietary information." 15 U.S.C.A. § 80b–4(b)(10) (2016). This includes, among other things, "sensitive nonpublic information" regarding the adviser's investment or trading strategies, analytical or research methodologies, and "software containing intellectual property." *Id.* However, the SEC's ethics rules (which are largely focused on former staff of the SEC making appearances before the agency) may allow SEC employees to leave the agency and work in the industry with the confidential knowledge that they acquire during the exam process. *Compare* Gregory Meyer & Phillip Stafford, *U.S. Regulators Propose Powers to Scrutinize Algo Traders' Source Code*, FIN. TIMES (Dec. 1, 2015) (discussing concerns of industry over Proposed Regulation AT, *see* Proposed CFTC Regulation AT and the Supplemental Notice of Proposed Rulemaking, *supra* note 228, which would require that trading firms make their source code available to the CFTC without a subpoena); *see also* Joe Mont, *CFTC Plan to Access Source Code Slammed as Regulatory Overreach*, COMPLIANCE WEEK (Nov. 7, 2016) (discussing a revision to the original CFTC proposal), https://www.complianceweek.com/blogs/the-filing-cabinet/cftc-plan-to-access-source-code-slammed-as-regulatory-overreach#.WQ-lUIEpDYU.

365. Although investment models are referred to by many as a "black box," they also may be considered "glass box" for regulatory purposes since they are relatively transparent compared to the decisions made by human managers. Compare *supra* note 27, discussing artificial intelligence.

els are a newer medium, the responsibilities of quantitative managers should be defined by analogous law developed in the context of research and the investment processes used by traditional advisers.

In many instances, traditional managers' decisions will not prove insightful. A traditional adviser, for example, may make analytical mistakes in examining investment opportunities that are material to its investment process or strategy, but which do not appear in a record other than its performance. Traditional advisers also may fail to examine all relevant information about a security as part of the research process, may rely on flawed traditional street research provided by third parties, or may base their decisions on incorrect data. And, they may overlook news or other relevant information; may misinterpret financial data; may employ an overly simplistic technique to gain diversification; may use an incorrect formula or inputs (e.g., discount or currency rates) to predict the fair value of stocks; may be away from the office during important events; or may reach incorrect conclusions based on interviews with management, information gathered during plant visits or factory tours, discussions with industry experts, or in their assessment of product pipelines or industry trends.[366] Further, traditional managers may also employ risk models and quantitative research techniques that are subject to the same imperfections as other quantitative models.

2. *Programming Errors Versus Other Errors or Mistakes*

The new standards suggested in the Orders also raise questions about how quickly any manager must modify or enhance its investment strategy based on changes in market conditions, new information, or new research. There is little analytical difference between data integrity problems, design flaws (including back testing), and programming errors in models. The way in which an adviser must address an error or flaw also is similar analytically to the way in which it addresses potential

366. Similarly, there should not be a distinction between quantitative managers who determine not to follow a model's recommendations precisely and traditional managers who may decide to temporarily exceed soft risk controls for benchmark concentrations. Consistent with its fiduciary duty and disclosure, managers may subjectively decide that it is beneficial to the investor not to follow a model's signals.

paradigm shifts in the market (e.g., LTCM) or signals produced by particular elements of its model that might have decayed (e.g., the presence of other managers employing similar factors diminished the return possibility an element of its strategy), and whether the manager also must disclose these events to investors.

As suggested above, one of the most dangerous false impressions that may be fostered by the Orders is that knowledge of a model error is different than other investment-related information that comes to a manager's attention—one that requires the manager to act in a specific manner. Traditional and quantitative investment managers both are confronted daily with macroeconomic, political and company specific information that may affect the portfolios that they manage. However, there is no law or regulation that dictates that a traditional manager must respond in one way or another to investment-related information, such as a new research report or the release of employment statistics, even though the information may affect a portfolio.[367]

Discovery of a defect in a model, like a change in the recommendation of a sell-side analyst, is new information that may be a single element factored into an adviser's investment decision-making process. Acting in good faith, quantitative managers may reasonably choose to act on the information, or not. Moreover, all managers should be able to reasonably rely on the sum of their education, training, and experience, as well as communication with colleagues, in reaching decisions based on the facts before them—even if the documentation of an action appears only rudimentary to the SEC staff.

3. *Third-Party Research Versus Internally-Developed Research*

Finally, a large segment of the industry relies on third parties to provide services, including investment models, tradi-

367. Specifically, a traditional manager is able to use its discretion and make a judgment about the relevance of the new information in the context of the totality of information available. For example, a traditional manager may act immediately upon discovering new material information or choose to delay acting on the information. By the same token, a traditional adviser normally would not be required by the SEC to disclose to investors that it made a mistake in the research leading to an investment decision—particularly if that mistake did not cause the manager to alter its view on a company or industry.

tional research reports, data, and technology that may contain errors. Traditional managers frequently rely, at least in part, on research[368] produced by investment banks or third-party researchers.[369] The use of third-party data and information by advisers (and manufacturers and merchants) is unavoidable. In addition, many traditional managers as well as quantitative managers also employ models developed by third parties (or affiliates) and licensed to subscribers.[370]

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368. In fact, the use of quantitative research techniques allows investment managers to rapidly analyze thousands of traditional research reports published by brokers or third-party research firms in order to detect trends that might predict market behavior.

369. The value ascribed to traditional research provided by brokers often is measured after the fact; and research providers regularly change their views. For example, managers often take regular "broker votes" in which research providers are rewarded with future brokerage commissions based on an assessment by portfolio managers of the value they attribute to the broker's research during an earlier period.

370. While the research affiliate in the Firm Order was registered with the SEC as an adviser, in many cases third-party model vendors are not registered advisers. *See* Firm Order, *supra* note 5. As noted earlier, at larger asset managers and financial institutions, research affiliates may develop and license proprietary software. Section 202(a)(11) of the Advisers Act, 15 U.S.C.A. § 80b–2(a)(11) (2016), defines "investment adviser" as any person who, for compensation, engages in the business of advising others as to the value of securities or as to the advisability of investing in, purchasing, or selling securities. However, under Section 202(a)(11)(D) of the Advisers Act, 15 U.S.C.A. § 80b–2(a)(11)(D) (2016), "the publisher of any bona fide newspaper, news magazine or business or financial publication of general and regular circulation" is not considered an investment adviser.

Relevant guidance applicable to third-party model developers is set forth in the U.S. Supreme Court's decision in *Lowe v. SEC*, 472 U.S. 181 (1985). In this case, the Supreme Court stated that the publications of any person relying on the publishers' exclusion may not be "personal communications masquerading in the clothing of newspapers, news magazines, or financial publications." *Id.* at 209. The publisher's exclusion would be available for model developers only so long as their model output remain "entirely impersonal and do[es] not develop into the kind of fiduciary, person-to-person relationships that . . . are characteristic of investment advisers-client relationships." *Id.* at 210 n.58. Factors that may be relevant to whether the developer of a third-party model may rely on the publishers' exclusion include the existence of authority over the funds of investors, any decision-making authority to handle client accounts, or individualized investment-related interactions. *Id.* at 210 n.57; *see also* 15 U.S.C. § 80b-3a; Weiss Research Inc., Advisers Act Release No. 2525, 88 SEC Docket 810 (June 22, 2006) (auto-trading program did not qualify for the publishers' exclusion because, un-

When a fiduciary uses a third party to perform some of its obligations, it must use prudence and reasonable care when selecting and overseeing their activities. Thus, the fiduciary generally is not liable for the actions of the third-parties if it exercises reasonable care, including appropriate due diligence.[371] This measure stands in stark contrast to the strict liability standard that the Orders appear to suggest applies to internally developed models. Accordingly, from a liability perspective, the SEC's Orders may favor reliance on third-party models over internally developed models.

The models developed by third-party vendors may be highly sophisticated, but have varying degrees of transparency. For example, frequently third-party models have relatively simple user interfaces that allow customization, but the computational analysis and programming is likely to be opaque to the user. Depending on the nature of the software, and the economic power of the parties, the manager may be able to conduct varying amounts of due diligence.[372] However, the vendors themselves are not subject to compliance oversight by the manager and, even if requested, detailed information about the proprietary elements of their models, including source code, is unlikely to be provided.[373] For this reason, reasonable due diligence, real-time monitoring, and independent safeguards provide the primary mechanisms to assure the integrity of third-party models.

It also is noteworthy that most software vendors, especially those providing investment tools, are not subject to a fiduciary standard, and often specifically disclaim that standard. Almost all commercial software and data licenses are provided on an

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like a typical newsletter, the entity engaged in personalized communications with its subscribers regarding investments).

371. The Restatement (Third) of Trusts provides that "a trustee who acts with prudence in delegating to an agent is not personally liable to the trust or beneficiary for the decisions or actions of the agent to whom the function is delegated." Restatement (Third) of Trusts § 80 cmt. g (AM. LAW. INST. 1998).

372. *Cf.* Robo-Adviser Guidance, *supra* note 149.

373. For pragmatic reasons, vendors may not be willing to provide their clients with complete access to proprietary information, including source code. Compare Robo-Adviser Guidance, *supra note* 149, in which the SEC Staff states that adviser compliance policies could address "oversight of third parties that may develop, own or manage algorithmic code or software utilized by the robo-adviser."

"as-is" basis, in which the vendor disclaims—in bold letters—any implied warranties of merchantability or fitness for a particular purpose, including any warranty for the use, or the results of the use, of the software with respect to its correctness, quality, accuracy, completeness, reliability, or performance, etc.[374] Moreover, the vendors emphatically disclaim any liability for consequential damages.[375] Thus, unlike trading errors in which a broker may sometimes be accountable for an error, an investment manager often has little recourse against third parties that supply data or models containing errors.[376]

CONCLUSION

The Advisers Act was written seventy-five years ago in a period in which managers focused on selecting "good" stocks for their client's portfolios. Since then, modern portfolio theory and the use of technology and quantitative research techniques have fundamentally changed the manner in which assets are managed, with the emphasis among many managers shifting from individual assets to portfolio characteristics. Investment information that formerly was the domain of traditional analysts and written research reports now may be revealed through quantitative research techniques and models. It also now is possible to use new data to forecast both

374. Normally, the research contains specific disclaimers stating that it represents an opinion or recommendation and that "information has been obtained from sources believed to be reliable" and the provider "does not warrant its completeness or accuracy." The reports also may note that "past performance is not indicative of future results" and that the provider is under no obligation to notify others if it changes its opinion.

375. Although specific disclaimers frequently are found in software licenses, under tort law, *services* such as software normally are subject to a negligence standard rather than the strict liability standard applied to *products* that cause physical injury. *See, e.g.*, David W. Lannetti, *Toward a Revised Definition of "Product" Under the Restatement (Third) of Torts: Products Liability*, 55 BUS. LAW. 799, 806–07 (2000).

376. Since the adviser may have no recourse against the vendor, it is unclear what obligation it would have to disclose a vendor error to investors although analytically the effect of the error is no different than an error in a model or research that is prepared internally. Similarly, a traditional manager that reasonably relies on third-party research should have no obligation to notify investors if it relied on the opinion of a third-party research analyst that makes a mistake and later issues a revised research report.

macroeconomic and single stock factors in ways that were not possible even ten years earlier.

Like traditional managers, the interests of quantitative advisers in almost all cases will be aligned with their investors, and model errors should not present a conflict-of-interest. Quantitative managers are highly incentivized to assure that their models work as intended at all times. Failure to achieve clients' investment objectives (due to market conditions, mistakes in investment judgment, or defects in a model) affects the manager's ability to attract or retain customer assets and to participate in the appreciation of portfolios through asset-based fees. For this reason, there is no policy reason for the SEC to impose a strict liability standard, which might result in significantly higher advisory fees for clients.

Because fiduciaries are not guarantors of performance, an adviser does not violate fiduciary standards or the disclosure requirements under Section 206 of the Advisers Act merely because of inevitable errors in its investment models. In contrast to the message that might be taken from the Orders, fiduciary principles and the securities laws do not require a manager to have "perfect" models, produce flawless research, to prophesize market movements, or otherwise make a manager strictly liable for the outcome of investment decisions made in good faith.

There is no justification for imposing a heightened standard of care on quantitative managers versus traditional managers. A quantitative manager's decision to delay correcting an error in a model is an investment decision, no different than an enhancement to a model, that should be subject to the same disclosure and fiduciary standards applied to traditional managers with respect to their research and investment decision-making responsibilities. For this reason, the SEC should not challenge the reasonable, good faith investment decisions of qualified quantitative managers (including the resolution of model errors), except to the extent that it would question analogous research or investment decisions made by qualified traditional managers.

From both a disclosure and fiduciary perspective, any analysis of the manager's prudence undertaken by the SEC also should consider the totality of the manager's model governance and investment decision-making process, not just pre-implementation controls. When quantitative investment mod-

els are properly considered as research, or decision support tools, the disparity between traditional managers and quantitative managers is not present and the analysis is more consistent with general fiduciary laws.

Some might attribute the Orders to the simple axiom "hard cases make bad law," suggesting that the unique facts of the first ever SEC cases involving errors in quantitative models do not define the agency's current policy. In fact, in recent years, based on statements by the SEC staff at conferences and elsewhere, the views of the SEC staff appear to be evolving with respect to models and model errors. For this reason, it is not clear how much precedential value to attribute to the Orders. However, it is very likely that the SEC and other regulators will continue to face challenges in drawing the line between business and investment-related functions of quantitative managers, and the activities that should be subject to regulation.