CFA INSTITUTE INVESTMENT PERSPECTIVES

Risk Management

Foundations for a Changing Financial World

Walter V. "Bud" Haslett Jr., CFA, Editor

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RISK MANAGEMENT

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RISK MANAGEMENT

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Walter V. "Bud" Haslett Jr., CFA

John Wiley & Sons, Inc.

Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
Published simultaneously in Canada.

ISBN 978-0-470-90339-1 (cloth); ISBN 978-0-470-93409-8 (ebk);
ISBN 978-0-470-93410-4 (ebk); ISBN 978-0-470-93411-1 (ebk)

Printed in the United States of America

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FOREWORD

Although risk management has always been an integral part of the investment management process, it has certainly become more prominent in recent years. By properly measuring and managing risk, the needs of clients and firms can be more effectively addressed. As the ever-evolving financial markets become more sophisticated and challenging, the application of risk management techniques must also evolve. This book traces that evolution from the perspective of some of the greatest minds in the investment management business.

The 53 individual chapters included in this book highlight two decades of risk management thought. They are taken from the Research Foundation of CFA Institute, *Financial Analysts Journal*, and CFA Institute conference proceedings series. The pieces represent works by Nobel Prize winners, industry legends, and a host of insightful academics and practitioners. The reader will be struck by the timelessness of the principles: An article written in the throes of the 1997 Asian currency crisis could easily be mistaken for one written after the most recent global financial meltdown.

The chapters are organized into three main sections. The first section provides an introduction and overview of risk management thought. The second section, which investigates the measurement of risk, focuses on risk modeling; it addresses such topics as value at risk, risk budgeting, and liquidity risk. The third section concentrates on risk management and issues related to asset classes, such as alternative investments. In addition, derivatives are explored, as well as the topical areas of credit, global, nonfinancial, and pension risk.

Risk Management: Foundations for a Changing Financial World represents the third in our CFA Institute Investment Perspectives Series and joins our previous works on private wealth management and investment performance management. We hope you will find it a useful guide and resource in addressing current issues as well as the many risk management challenges you may face in the future.

Robert R. Johnson, PhD, CFA
Senior Managing Director
CFA Institute

ACKNOWLEDGMENTS

It has been one of the greatest honors of my professional career to review and select the risk management works included in this book. My sincerest appreciation goes out to CFA Institute for entrusting me with this great responsibility. In particular, I would like to thank Heather Packard; Stephen Horan, PhD, CFA; and Rodney Sullivan, CFA, for all of their help along the way, and Tom Robinson, PhD, CFA, and John Rogers, CFA, whose division and organization, respectively, green-lighted the project. In addition, many thanks to Bob Johnson, PhD, CFA, who wrote the Foreword to this book; and Peter Went, PhD, CFA, who co-wrote the Introduction.

Special acknowledgment goes out to the contributors who provided the valuable insights that we are so very proud to share with you and to everyone involved with the *Financial Analysts Journal*, *Conference Proceedings Quarterly,* and Research Foundation of CFA Institute for making the publication of this information possible. John Wiley & Sons' excellent contribution to the actual publication of this book must also be recognized.

I would also like to thank everyone who has contributed knowledge to the field of risk management and to the Global Association of Risk Professionals (GARP) and the Professional Risk Managers International Association (PRMIA) for their excellent work. Risk management affects all of us in the investment business, and it is through global cooperation that we can all benefit from what has been learned in this field and what will be learned in the future.

Walter V. "Bud" Haslett Jr., CFA

INTRODUCTION

Risk is an integral part of virtually every decision we make. In a modern portfolio theory framework, risk and return are two required inputs as we seek to maximize returns at a given level of risk. This task is further simplified by the assumption that an asset providing a higher rate of return is riskier than an asset providing a lower rate of return. In this process, risk is assumed to be known and quantified. Standard deviation, variance, and volatility offer simple and tangible metrics to quantify the amount of risk at play.

Because risk is quantifiable, it should be easily predictable and readily manageable. Using various statistical and nonstatistical approaches, risk measures can be calculated and used to predict the impact risks may have on the performance of the portfolio. These methods allow for managing the risks that *we know that we know*, such as small price and yield changes. For this task, we can use the various financial tools that have developed over the years to manage the effects of these types of risks.

How to manage the risks that *we know that we do not know* remains a challenge, even though reoccurring financial crises generously generate ample data to analyze, observe, and extrapolate.

But the real challenge in managing risks in investment management is managing and measuring the impact of risks that *we do not know that we do not know*. These risks, such as extreme tail risks or black swan events, are risks that we cannot fully comprehend, imagine, or possibly conceive in advance. These types of risks are made even more challenging by the fact that they fail to occur independently and often experience significant and rapidly shifting correlation between various risk events. Although a skilled risk manager could compute, with relative ease, the separate impact of each of these risks in advance, the collective effect of these events would be almost impossible to quantify and predict.

Because risk management is about learning from experience, the difference between good and bad risk management is how to best consider risk in the context of the investment decision-making process. Even if all possible risks are known in advance, are quantifiable, and are considered, some remaining challenges can affect the outcome. Equity prices, interest rates, and foreign exchange rates are innately volatile, and this continuous, unpredictable, and unexpected volatility is a fact of life. As long as these changes are small and not significant, the existing risk metrics and risk management tools available to manage these everyday risk events should be adequate. But oftentimes these changes are not insignificant. It appears that, in managing risks, the only certainty is that risks are uncertain.

The chapters in this book summarize much of our current knowledge and understanding of risks and risk management. The permanence of risk shines through in each of them. This enduring nature is particularly evident when comparing the risk events in the 1990s with those of the events of the latter half of the first decade of the 2000s. The lessons were there for all to see and learn, and they remind us that there are more lessons to learn.

In the Overview (Part I) of the book, we first address lessons learned from the 1990s with articles and conference proceedings from Richard Bookstaber, Jacques Longerstaey, Andrew Lo, and Robert Kopprasch, CFA. The 1990s was a decade dominated by Barings Bank, Long-Term Capital Management, and the Asian contagion, and many of these works reflect lessons learned directly from those incidents. From discussions on liquidity to the organizational structure needed to effectively manage risk, these chapters provide timeless insights for all investment professionals.

The second portion of the Overview (2000 to the present) begins with a comprehensive Research Foundation piece by Sébastien Lleo, CFA, and is followed by works from Glyn Holton, Aswath Damodaran, Tyler Cowen, Bluford Putnam, and Sykes Wilford. Besides being affected by the decade's events, such as the bursting of the tech bubble and the housing crisis, these chapters include a healthy discussion of the qualitative nature of risk management, which is an important theme running throughout the book. To be successful, risk management needs to contain a strong quantitative component, but if viewed in isolation, these measures alone will be inadequate. It is when the quantitative measures are combined with well-informed qualitative insights that risk management can become truly effective.

Works from Max Darnell; Philippe Jorion; Michelle McCarthy; Bennett Golub; Mark Kritzman, CFA, and Don Rich; Roland Lochoff; Don Ezra; Arjan Berkelaar, CFA, Adam Kobor, CFA, and Masaki Tsumagari, CFA; Richard Bookstaber; James Bennett, CFA, and Richard Sias; John Bogle; and Richard Ennis, CFA, in Part II: Measuring Risk address many quantitative aspects of risk management, including limitations of popular measures and the dangers of extreme events (such as the previously mentioned tail risk and black swan events). Correlated and uncorrelated returns as well as analysis of volatility are also discussed in this section.

In Part III: Managing Risk, a broad grouping of chapters is organized into several different subsections. Because of the increasing importance and complexity of alternative investment strategies, Andrew Lo, Leslie Rahl, Clifford Asness, Luke Ellis, and Burton Malkiel and Atanu Saha discuss the unique risk issues in this area. Nonnormal distributions, distinct characteristics of hedge funds and fund-of-funds investments, and the question of return persistency are all discussed in these timely works.

Jeremy Graveline and Michael Kokalari, Bruce Jacobs, and Robert Merton discuss credit risk in a grouping of chapters covering such topics as collateralized debt obligations (CDOs), credit default swaps (CDSs), and the pricing of credit risk. These more recent chapters precede and follow the credit crisis and provide an eye-opening analysis of developments before, during, and after this most challenging period of time.

The nature of the financial crisis and the regulatory debates of 2008 and 2009 cry out for special attention to derivatives, which are discussed by Joanne Hill, Mark Brickell, Maarten Nederlof, Charles Smithson, and Robert McLaughlin. Again, the reader will note the vintage of some of these works and the power of their insights. It is truly remarkable how many of the derivatives issues of the past (such as rising correlations in a time of crisis, impact of outlier events, and fiduciary responsibilities) are still derivatives issues of the present, despite the passing of more than a decade.

The timelessness of risk management principles is also apparent in the Global Risk subsection, which features articles from Charles Tschampion, CFA; Fischer Black; Mark Kritzman, CFA; Gifford Fong; Marvin Zonis; and Claude Erb, CFA, Campbell Harvey, and Tadas Viskanta. Global investing has expanded dramatically over the past 20 years, yet these articles are still providing a wealth of information for dealing with the challenges of increasing currency volatility, sovereign risk, and the many other intricacies we face in our increasingly global economies and investment universe.

Works in the Nonfinancial Risk subsection of Managing Risk are from such notable experts as Andrew Lo, Arnold Wood, Robert Swan, Emanuel Derman, Douglas Breeden, and Meir Statman and address many operational, behavioral, and model risk issues not covered in other sections. The challenges during the credit crisis highlighted many of these issues, and particular attention to the concepts will assist with developing a framework to minimize such negative impacts in the future.

Rounding out the Managing Risk section is the subsection Pension Risk, with works from William Sharpe; Desmond Mac Intyre; Christopher Campisano, CFA; Leo de Bever; and Roman von Ah. From manager and marginal risk to liability-driven investing, as an increasingly large group of the global population enters and approaches retirement age, these issues are sure to provide valuable insights into this critically important area.

The risk involved with using timeless articles is that, although the concepts are fundamentally sound, the data are dated. This is particularly true of the "Country Risk in Global Financial Management" and Fischer Black chapters. Nonetheless, the data serve as a trip down memory lane for those who experienced the information firsthand, or provide a valuable reference point for those who were not involved in the investment business at that time.

Any emphasis implied by either the number of articles or the number of pages in any particular section is unintentional because all topics addressed are important to risk management. Risk, like water, tends to seek out and find weaknesses in structure, and so strength in all areas is the best defense against the unintended ravages that poor risk management can bring.

Because risk management affects so many areas of investment management, the information in this book will provide value to a broad cross section of investment professionals. We are delighted to present this timeless wealth of information for all to use and enjoy, and we hope the insights learned will lead to much success for you, your clients, and your firm.

Walter V. "Bud" Haslett Jr., CFA
Peter Went, PhD, CFA

PART I

OVERVIEW—TWO DECADES OF RISK MANAGEMENT

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CHAPTER 1

A FRAMEWORK FOR UNDERSTANDING MARKET CRISIS*

Richard M. Bookstaber

The key to truly effective risk management lies in the behavior of markets during times of crisis, when investment value is most at risk. Observing markets under stress teaches important lessons about the role and dynamics of markets and the implications for risk management.

No area of economics has the wealth of data that we enjoy in the field of finance. The normal procedure we apply when using these data is to throw away the outliers and focus on the bulk of the data that we assume will have the key information and relationships that we want to analyze. That is, if we have 10 years of daily data—2,500 data points—we might throw out 10 or 20 data points that are totally out of line (e.g., the crash of 1987, the problems in mid-January 1991 during the Gulf War) and use the rest to test our hypotheses about the markets.

If the objective is to understand the typical day-to-day workings of the market, this approach may be reasonable. But if the objective is to understand the risks, we would be making a grave mistake. Although we would get some good risk management information from the 2,490 data points, unfortunately, that information would result in a risk management approach that works almost all the time but does not work when it matters most. This situation has happened many times in the past: Correlations that looked good on a daily basis suddenly went wrong at exactly the time the market was in turmoil; value at risk (VAR) numbers that tracked fairly well day by day suddenly had no relationship to what was going on in the market. In the context of effective risk management, what we really should do is throw out the 2,490 data points and focus on the remaining 10 because they hold the key to the behavior of markets when investments are most at risk.

*Reprinted from *AIMR Conference Proceedings: Risk Management: Principles and Practices* (August 1999): 7–19.

This presentation considers the nature of the market that surrounds those outlier points, the points of market crisis. It covers the sources of market crisis and uses three case studies—the equity market crash of 1987, the problems with the junk bond market in the early 1990s, and the recent problems with Long-Term Capital Management (LTCM)—to illustrate the nature of crisis and the lessons for risk management. This presentation also addresses several policy issues that could influence the future of risk management.

SOURCES OF CRISIS

The sources of market crisis lie in the nature and role of the market, which can be best understood by departing from the mainstream view of the market.

Market Efficiency

The mainstream academic view of financial markets rests on the foundation of the efficient market hypothesis. This hypothesis states that market prices reflect all information. That is, the current market price is the market's "best guess" of where the price should be. The guess may be wrong, but it will be unbiased; it is as likely to be too high as too low. In the efficient market paradigm, the role of the markets is to provide estimates of asset values for the economy to use for planning and capital allocation. Market participants have information from different sources, and the market provides a mechanism that combines the information to create the full information market price. Investors observe that price and can plan efficiently by knowing, from that price, all of the information and expectations of the market.

A corollary to the efficient market hypothesis is that, because all information is already embedded in the markets, no one can systematically make money trading without nonpublic information. If new public information comes into the market, the price will instantaneously move to its new fair level before anybody can make money on that new information. At any point in time, just by luck, some traders will be ahead in the game and some will be behind, but in the long run, the best strategy is simply to buy and hold the overall market.

I must confess that I never felt comfortable with the efficient market approach. As a graduate student who was yet to be fully indoctrinated into this paradigm, I could look at the many simple features of the market that did not seem to fit.

Why do intraday prices bounce around as much as they do? The price of a futures contract in the futures market or a stock in the stock market moves around much more than one would expect from new information coming in. What information could possibly cause the price instantaneously to jump two ticks, one tick, three ticks, two ticks second by second throughout the trading day?

How do we justify the enormous overhead of having a continuous market with real-time information? Can that overhead be justified simply on the basis of providing the marketplace with price information for planning purposes? In the efficient market context, what kind of planning would people be doing in which they had to check the market and instantly make a decision on the basis of a tick up or down in price?

Liquidity and Immediacy

All someone has to do is sit with a broker/dealer trader to see that more than information is moving prices. On any given day, the trader will receive orders from the derivative desk to

hedge a swap position, from the mortgage desk to hedge out mortgage exposure, and from clients who need to sell positions to meet liabilities. None of these orders will have anything to do with information; each one will have everything to do with a need for liquidity.

And the liquidity is manifest in the trader's own activities. If inventory grows too large and the trader feels overexposed, the trader will aggressively hedge or liquidate a portion of the position, and the trader will do so in a way that respects the liquidity constraints of the market. If the trader needs to sell 2,000 bond futures to reduce exposure, the trader does not say, "The market is efficient and competitive, and my actions are not based on any information about prices, so I will just put those contracts in the market and everybody will pay the fair price for them." If the trader puts 2,000 contracts into the market all at once, that offer obviously will affect the price, even though the trader does not have any new information. Indeed, the trade would affect the market price even if the market *knew* the trader was selling without any informational edge.

The principal reason for intraday price movement is the demand for liquidity. A trader is uncomfortable with the level of exposure and is willing to pay up to get someone to take the position. The more uncomfortable the trader is, the more the trader will pay. The trader has to pay up because someone else is getting saddled with the risk of the position—someone who most likely did not want to take on that position at the existing market price because otherwise, that person would have already gone into the market to get it.

This view of the market is a liquidity view rather than an informational view. In place of the conventional academic perspective of the role of the market, in which the market is efficient and exists solely for informational purposes, this view is that the role of the market is to provide immediacy for liquidity demanders. The globalization of markets and the Widespread dissemination of real-time information have made liquidity demand all the more important. With more and more market information disseminated to a wider and wider set of market participants, less opportunity exists for trading based on an informational advantage, and the growth of market participants means there are more incidents of liquidity demand.

To provide this immediacy for liquidity demanders, market participants must exist who are liquidity suppliers. These liquidity suppliers must have free cash available, a healthy risk appetite, and risk management capabilities, and they must stand ready to buy and sell assets when a participant demands that a transaction be done immediately. By accepting the notion that markets exist to satisfy liquidity demand and liquidity supply, the framework is in place for understanding what causes market crises, which are the times when liquidity and immediacy matter most.

Liquidity Demanders

Liquidity demanders are demanders of immediacy: a broker/dealer who needs to hedge a bond purchase taken on from a client, a pension fund that needs to liquidate some stock position because it has liability outflow, a mutual fund that suddenly has some inflows of cash that it has to put into the index or the target fund, or a trader who has to liquidate because of margin requirements or because of being at an imposed limit or stop-loss level in the trading strategy. In all these cases, the defining characteristic is that time is more important than price. Although these participants may be somewhat price sensitive, they need to get the trade done immediately and are willing to pay to do so. A huge bond position can lose a lot more if the bondholder haggles about getting the right price rather than if the bondholder just pays up a few ticks to put the hedge on. Traders who have hit their risk limits do not have any choice; they are going to get out, and they are not in a good position to argue whether or

not the price is right or fair. One could think of liquidity demanders as the investors and the hedgers in the market.

Liquidity Suppliers

Liquidity suppliers meet the liquidity demand. Liquidity suppliers have a view of the market and take a position in the market when the price deviates from what they think the fair price should be. To liquidity suppliers, price matters much more than time. For example, they try to take a cash position or an inventory position that they have and wait for an opportunity in which the liquidity demander's need for liquidity creates a divergence in price. Liquidity suppliers then provide the liquidity at that price.

Liquidity suppliers include hedge funds and speculators. Many people have difficulty understanding why hedge funds and speculators exist and why they make money in an efficient market. Their work seems to be nothing more than a big gambling enterprise; none of them should consistently make money if markets are efficient. If they did have an informational advantage, it should erode over time, and judging by their operations, most speculators and traders do not have an informational advantage, especially in a world awash in information.

So, why do speculators and liquidity suppliers exist? What function do they provide? Why do, or should, they make money? The answer is that they provide a valuable economic function. They invest in their business by keeping capital readily available for investment and by applying their expertise in risk management and market judgment. They want to find the cases in which a differential exists in price versus value, and they provide the liquidity. In short, they take risk, use their talents, and absorb the opportunity cost of maintaining ready capital. For this functionality, they receive an economic return.

The risk of providing liquidity takes several forms. First, a trader cannot know for sure that a price discrepancy is the result of liquidity demand. The discrepancy could be caused by information or even manipulation. But suppose somebody waves a white flag and announces that they are trading strictly because of a liquidity need; they have no special information or view of the market and are willing to discount the price an extra point to get someone to take the position off their hands. The trader who buys the position still faces a risk, because no one can guarantee that between the time the trader takes on the position and the time it can be cleared out the price will not fall further. Many other liquidity-driven sellers may be lurking behind that one, or a surprise economic announcement might affect the market.

The liquidity supplier should expect to make money on the trade, because there is an opportunity cost in holding cash free for speculative opportunities. The compensation should also be a function of the volatility in the market; the more volatile the market, the higher the probability in any time period that prices will run away from the liquidity suppliers. In addition, their compensation should be a function of the liquidity of the market; the less liquid the market, the longer they will have to hold the position and thus the longer they will be subject to the volatility of the market.

Interaction of Liquidity Supply and Demand in a Market Crisis

A market behaves qualitatively differently in a market crisis than in "normal" times. This difference is not a matter of the market being "more jumpy" or of a lot more news suddenly flooding into the market. The difference is that the market reacts in a way that it does not in normal times. The core of this difference in behavior is that market prices become countereconomic.

The normal economic consequence of a decline in market prices is that fewer people have an incentive to sell and more people have an incentive to buy. In a market crisis, everything goes the wrong way. A falling price, instead of deterring people from selling, triggers a growing flood of selling, and instead of attracting buyers, a falling price drives potential buyers from the market (or, even worse, turns potential buyers into sellers). This outcome happens for a number of related reasons: Suppliers who were in early have already committed their capital; suppliers turn into demanders because they have pierced their stop-loss levels and must liquidate their holdings; and others find the cost of business too high with widening spreads, increased volatility, and reduced liquidity making the risk-return trade-offs of market participation undesirable. It is as if the market is struck with an autoimmune disease and is attacking its own system of self-regulation.

An example of this drying up of supply can be seen during volatility spikes. Almost every year in some major market, option volatilities go up to a level that no rational person would think sustainable. During the Asian crisis in 1998, equity market volatility in the United States, Hong Kong, and Germany more than doubled. During the exchange rate crisis in September 1993, currency volatility went up manyfold. During the oil crisis that accompanied the Gulf War, oil volatilities exceeded 80 percent. Volatilities for stocks went from the mid-teens to more than 100 percent in the crash of 1987. Did option traders really think stock prices would be at 100 percent volatility levels during the three months following the crash? Probably not. But the traders who normally would have been available to take the other side of a trade were out of the market. At the very time everybody needed the insurance that options provide and was willing to pay up for it, the people who could sell that insurance were out of the market. They had already "made their move," risking their capital at much lower levels of volatility, and now were stopped out of their positions by management or, worse still, had lost their jobs.

Even those who still had their jobs kept their capital on the sidelines. Entering the market in the face of widespread destruction was considered imprudent, and the cost of entry was (and still is) fairly high. Information did not cause the dramatic price volatility. It was caused by the crisis-induced demand for liquidity at a time that liquidity suppliers were shrinking from the market.

Market Habitat

All investors and traders have a market habitat where they feel comfortable trading and committing their capital—where they know the market, have their contacts in the market, have a feel for liquidity, know how the risks are managed, and know where to look for information. The habitat may be determined by an individual's risk preferences, knowledge, experience, time frame and institutional constraints, and by market liquidity. Investors will roam away from their habitat only if they believe incremental returns are available to them. Someone who is used to trading in technology stocks will need more time for evaluation and a better opportunity to take a position in, say, the automotive sector, than in the more familiar technology sector.

Nowadays, the preferred market habitat for most investors and traders is expanding because of low barriers to entry and easy access to information. Anyone can easily set up an account to trade in many markets, ranging from the G–7 countries to the emerging markets. Anyone can get information—often realtime information—on a wide variety of bonds and stocks that used to be available only to professionals. The days of needing to call a broker to check up on the price of a favorite stock now seem a distant memory.

More information and fewer barriers to entry expand habitat. Higher levels of risk also tend to expand habitat. The distinction among assets blurs as risk increases. In addition, market participants become more like one another, which means that liquidity demanders all demand pretty much the same assets and grab whatever sources of liquidity are available. This situation is characterized in the market as "contagion," but in my view, what is happening is an expansion of habitat because the risk of the market has made every risky asset look pretty much the same. If all investors are in the same markets, they will run into trouble at the same time and will start liquidating the same markets to get financing and reduce their risks.

Think of how the investor's focus shifts as the investor moves from a normal market environment to a fairly energetic market environment, and then to a crash environment. In a normal market, investors have time to worry about the little things: the earnings of this company versus that company, P/Es, dividends, future prospects, and who is managing what. As the energy level goes up in the market, investors no longer have the luxury of considering the subtleties of this particular stock or that stock. They need to concentrate on sectors. If the technology sector is underperforming, all technology stocks look the same. If oil prices go up, an oil company's management and earnings prospects no longer matter; all that matters is that the company is in the energy sector. Turn the heat up further to a crash environment and all that participants care about is that it is a stock and that they can sell it. All stocks look the same, and the correlations get close to 1.0 because the only characteristic that matters is that this asset is a stock or, for that matter, is risky. In fact, the situation can get even worse; junk bonds may be viewed to be similar enough to stocks that they trade like stocks. The analysis and market history of the normal market environment no longer applies. The environment is different; the habitat has changed.

An analogy from high-energy physics helps to illustrate the situation. As energy increases, the constituents of matter blur. At low energy levels—room temperature—molecules and atoms are distinct and differentiated. As energy goes up, the molecules break apart and what is left are the basic building blocks of matter, the elements. As energy goes up even more, the atoms break apart and plasma is left. Everything is a defused blob of matter.

As the energy of the market increases, the same transformation happens to the constituents of the market. In a market crisis, all the distinct elements of the market—the stocks (e.g., IBM and Intel), the market sectors (e.g., technology and transportation), the assets (e.g., corporate bonds and swap spreads)—turn into an undifferentiated plasma. Just as in high-energy physics, where all matter becomes an undifferentiated "soup," in the high-energy state of a market crisis, all assets blur into undifferentiated risk.

One of the most troubling aspects of a market crisis is that diversification strategies fail. Assets that are uncorrelated suddenly become highly correlated, and all the positions go down together. The reason for the lack of diversification is that in a high-energy market, all assets in fact *are* the same. The factors that differentiate them in normal times are no longer relevant. What matters is no longer the economic or financial relationship between assets but the degree to which they share habitat. What matters is who holds the assets. If mortgage derivatives are held by the same traders as Japanese swaps, these two types of unrelated assets will become highly correlated because a loss in the one asset will force the traders to liquidate the other. What is most disturbing about this situation is not that the careful formulation of an optimized, risk-minimizing portfolio turns to naught but that there is no way to determine which assets will be correlated with which other assets during a market crisis. That is, not only will diversification fail to work at the very time it is most critical, but determining the way in which it will fail will be impossible.