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# QUANTITATIVE RISK MANAGEMENT

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A Practical Guide to  
Financial Risk

**Thomas S. Coleman**

*Foreword by* **Bob Litterman**

# Quantitative Risk Management

*A Practical Guide  
to Financial Risk*

THOMAS S. COLEMAN



WILEY

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# **Quantitative Risk Management**

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*To Lu and Jim, for making me who I am today.*

## Foreword

**H**aving been the head of the risk management department at Goldman Sachs for four years (which I sadly feel obligated to note was many years ago during a period when the firm was a highly respected private partnership), and having collaborated on a book called *The Practice of Risk Management*, I suppose it is not a surprise that I have a point of view about the topic of this book.

Thomas Coleman also brings a point of view to the topic of risk management, and it turns out for better or for worse, we agree. A central theme of this book is that “in reality risk management is as much the art of managing people, processes, and institutions as it is the science of measuring and quantifying risk.” I think he is absolutely correct.

This book’s title also highlights an important distinction that is sometimes missed in large organizations. Risk measurement, per se, which is a task usually assigned to the “risk management” department, is in reality only one input to the risk management function. As Coleman elaborates, “Risk measurement tools . . . help one to understand current and past exposures, a valuable and necessary undertaking but clearly not sufficient for actually managing risk.” However, “The art of risk management” which he notes is squarely the responsibility of senior management, “is not just in responding to anticipated events, but in building a culture and organization that can respond to risk and withstand unanticipated events. In other words, risk management is about building flexible and robust processes and organizations.”

The recognition that risk management is fundamentally about communicating risk up and managing risk from the top leads to the next level of insight. In most financial firms different risks are managed by desks requiring very different metrics. Nonetheless, there must be a comprehensive and transparent aggregation of risks and an ability to disaggregate and drill down. And as Coleman points out, consistency and transparency in this process are key requirements. It is absolutely essential that all risk takers and risk managers speak the same language in describing and understanding their risks.

Finally, Coleman emphasizes throughout that the management of risk is not a function designed to minimize risk. Although risk is usually a reference to the downside of random outcomes, as Coleman puts it, risk management is about taking advantage of opportunities: “controlling the downside and exploiting the upside.”

In discussing the measurement of risk the key concept is, of course, the distribution of outcomes. But Coleman rightly emphasizes that this distribution is unknown, and cannot be summarized by a single number, such as a measure of dispersion. Behavioral finance has provided many illustrations of the fact that, as Coleman notes, “human intuition is not very good at working with randomness and probabilities.” In order to be successful at managing risk, he suggests, “We must give up any illusion that there is certainty in this world and embrace the future as fluid, changeable, and contingent.”

One of my favorite aspects of the book is its clever instruction on working with and developing intuition about probabilities. Consider, for example, a classic problem, that of interpreting medical test results. Coleman considers the case of testing for breast cancer, a disease that afflicts about one woman in twenty. The standard mammogram tests actually report false positives about five percent of the time. In other words, a woman without cancer will get a negative result 95 percent of the time and a positive result 5 percent of the time. Conditional on receiving a positive test result, a natural reaction is to assume the probability of having cancer is very high, close to 95 percent. In fact, that is not true. Consider that out of 1,000 women approximately 5 will have cancer. Approximately 55 will receive positive results. Thus, conditional on receiving a positive test result the probability of having cancer is only about 9 percent, not 95 percent. Using this example as an introduction, the author then develops the ideas of Bayesian updating of probabilities.

Although this book appropriately spends considerable effort describing quantitative risk measurement techniques, that task is not its true focus. It takes seriously its mission as a practical guide. For example, in turning to the problem of managing risk, Coleman insightfully chooses as his first topic managing people, and the first issue addressed is the principal-agent problem. According to Coleman, “Designing compensation and incentive schemes has to be one of the most difficult and underappreciated, but also one of the most important, aspects of risk management.” Although he does not come to a definitive conclusion about how to structure employment contracts, he concludes, “careful thinking about preferences, incentives, compensation, and principal-agent problems enlightens many of the most difficult issues in risk management—issues that I think we as a profession have only begun to address in a substantive manner.”



There are many well-known limitations to any attempt to quantify risk, and this book provides a useful cautionary list. Among the many concerns, Coleman highlights that “models for measuring risk will not include all positions and all risks”; “risk measures such as VaR and volatility are backward looking”; “VaR does not measure the ‘worst case’”; “quantitative techniques are complex and require expertise and experience to use properly”; and finally, “quantitative risk measures do not properly represent extreme events.” And perhaps most significantly, while he discusses many of the events of the recent financial crisis, Coleman makes the useful distinction between idiosyncratic risk, which can be managed by a firm, versus systemic risk which arises from an economy-wide event outside the control of the firm. This book is focused on the former. Nonetheless, with respect to the latter he concludes that “Systemic risk events . . . are far more damaging because they involve substantial dislocations across a range of assets and across a variety of markets. Furthermore, the steps a firm can take to forestall idiosyncratic risk events are often ineffective against systemic events.”

Coleman brings to bear some of the recent insights from behavioral finance, and in particular focuses on the problem of overconfidence, which is, in his words, “the most fundamental and difficult (issue) in all of risk management, because confidence is necessary for success, but overconfidence can lead to disaster.” Later he elaborates, “Risk management . . . is also about managing ourselves. Managing our ego, managing our arrogance, our stubbornness, our mistakes. It is not about fancy quantitative techniques but about making good decisions in the face of uncertainty, scanty information, and competing demands.” In this context he highlights four characteristics of situations that can lead to risk management mistakes, familiarity, commitment, the herding instinct, and belief inertia.

When focusing on the understanding and communication of risk, Coleman delves deeply into a set of portfolio analysis tools which I helped to develop and utilize while managing risk at Goldman Sachs. These tools, such as the marginal contribution to risk, risk triangles, best hedges, and the best replicating portfolio, were all designed to satisfy the practical need to simplify and highlight the most important aspects of inherently complex combinations of exposures. As we used to repeat often, risk management is about communicating the right information to the right people at the right time.

After covering the theory, the tools, and the practical application, Coleman finally faces the unsatisfying reality that the future is never like the past, and this is particularly true with respect to extreme events. His solution is to recognize this limitation. “Overconfidence in numbers and

quantitative techniques, in our ability to represent extreme events, should be subject to severe criticism, because it lulls us into a false sense of security.” In the end the firm relies not so much on the risk measurement tools as the good judgment and wisdom of the experienced risk manager. As Coleman correctly concludes, “A poor manager with good risk reports is still a poor manager. The real risk to an organization is in the unanticipated or unexpected—exactly what the quantitative measures capture least well and what a good manager must strive to manage.”

BOB LITTERMAN  
Partner, Kepos Capital

## Preface

*Risk management is the art of using lessons from the past to mitigate misfortune and exploit future opportunities—in other words, the art of avoiding the stupid mistakes of yesterday while recognizing that nature can always create new ways for things to go wrong.*

**T**his book grew out of a project for the Research Foundation of the CFA Institute. The Research Foundation asked me to write a monograph, a short and practical guide to risk management. I took the commission as a license to write about how I *think* about risk. Ultimately the project grew far beyond the original mandate and into this book, a book that is, I hope, still a practical guide to financial risk management.

In this book I lay out my view of risk management, a view that has developed over many years as a researcher, trader, and manager. My approach is a little idiosyncratic because risk management itself suffers from a split personality—one side soft management skills, the other side hard mathematics—and any attempt to treat both in the same book will by its nature be something of an experiment. In writing this book I want to do more than just write down the mathematical formulae; I want to explain how we should think about risk, what risk means, why we use a particular risk measure. Most importantly, I want to challenge the accepted wisdom that risk management is or ever should be a separate discipline; managing risk is central to managing a financial firm and must remain the responsibility of anyone who contributes to the profit of the firm.

I entered the financial industry as a trader on a swaps desk. On the desk we lived by the daily and monthly profit and loss. There was nothing more important for managing that P&L than understanding and managing the risk. Risk was around us every day and we needed to build and use practical

tools that could help us understand, display, report, and manage risk in all its complexity and variety.

The experience on a trading desk taught me that managing risk is the central part of a financial business. Managing risk is not something to be delegated, not something to be handed over to a risk management department. The measurement of risk can certainly be technical and may require quantitative expertise and a cadre of risk professionals, but the responsibility for management ultimately resides with line managers, senior management, and the board. This lesson is as true for a commercial bank or a portfolio manager as for a trading desk. In any financial business, it is managers who must manage risk, and true risk management can never be devolved to a separate department.

The necessity to manage risk in today's complex markets leads to an inevitable tension between the management side and the quantitative side. Managers traditionally focus on people, process, institutions, incentives—all the components of managing a business. Risk professionals focus on mathematics, models, statistics, data—the quantitative side of the business. Successful performance in today's markets requires that a firm bridge this split personality and integrate both management and quantitative skills.

This book tries to address both sides of the divide. Part One, comprising Chapters 1 through 6, focuses on the management side. I argue that managing risk is as much about managing people, processes, and institutions as it is about numbers, and that a robust and responsive organization is the best tool for responding to a risky environment. But managers also need to be comfortable with quantitative issues: What is risk? How should we think about uncertainty and randomness? What do the quantitative measures such as volatility and VaR mean? These are not just mathematical questions. We need to understand the intuition behind the formulae and use our knowledge to help make decisions.

Part One is not addressed at managers alone. Risk professionals, those focused on building the models and producing the numbers, need to understand how and why the numbers are used in managing risk. As Kendall and Stuart so rightly say, "It's not the figures themselves, it's what you do with them that matters." Part One aims to lay out the common ground where managers and risk professionals meet for the task of measuring and managing risk.

Part Two changes gears to focus on the quantitative tools and techniques for measuring risk. Modern risk measurement *is* a quantitative field, often the preserve of specialists with mathematical training and expertise. There is no avoiding the statistics, mathematics, and computer technology necessary for risk measurement in today's markets. But we should not shy away from these challenges. The ideas are almost always straightforward,

even if the details are difficult. I try to be thorough in covering the theory but also explain the ideas behind the theory. Throughout the book I work with a consistent but simple portfolio to provide examples of key ideas and calculations. Purchasers of the book can access many of these examples online to explore the concepts more fully.

Part Two is aimed primarily at risk professionals, those who need to know the exact formula for calculating, say, the contribution to risk. But managers can also use Part Two to learn more about the concepts behind risk measurement. Chapters 9 and 10 in particular focus on examples and using risk measurement tools. This book should serve as more than simply a reference on how to calculate volatility or learn what a generalized Pareto distribution is. My goal throughout is to find simple explanations for complex concepts—more than anything, I had to explain these concepts to myself.

In the end, this book will be a success if readers come away with both an appreciation of risk management as a management endeavor, and a deeper understanding of the quantitative framework for measuring risk. I hope managers can use this to increase their quantitative skills and knowledge, and that risk professionals can use it to improve their understanding of how the numbers are used in managing the business.

Thomas S. Coleman  
Greenwich, CT  
March 2012



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*"You haven't told me yet," said Lady Nuttal, "what it is your fiancé does for a living."*

*"He's a statistician," replied Lamia, with an annoying sense of being on the defensive.*

*Lady Nuttal was obviously taken aback. It had not occurred to her that statisticians entered into normal social relationships. The species, she would have surmised, was perpetuated in some collateral manner, like mules.*

*"But Aunt Sara, it's a very interesting profession," said Lamia warmly.*

*"I don't doubt it," said her aunt, who obviously doubted it very much. "To express anything important in mere figures is so plainly impossible that there must be endless scope for well-paid advice on how to do it. But don't you think that life with a statistician would be rather, shall we say, humdrum?"*

*Lamia was silent. She felt reluctant to discuss the surprising depth of emotional possibility which she had discovered below Edward's numerical veneer.*

*"It's not the figures themselves," she said finally, "it's what you do with them that matters."*

—K.A.C. Manderville, *The Undoing of Lamia Gurdleneck*,  
quoted in Kendall and Stuart (1979, frontispiece).

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