

Preface

This book presents sound principles and useful methods for making investment and risk management decisions in the presence of hedgeable and nonhedgeable risks.

In everyday life we are often forced to make decisions involving risks and perceived opportunities. The consequences of our decisions are affected by the outcomes of random variables that are to various degrees beyond our control. Such decision problems arise, for instance, in financial and insurance markets. What kind of insurance should you buy? What is an appropriate way to invest money for later stages in life or for building a capital buffer to guard against unforeseen events? While private individuals may choose not to take a quantitative approach to investment and risk management decisions, financial institutions and insurance companies are required to quantify and report their risks. Financial institutions and insurance companies have assets and liabilities, and their investment actions involve both speculation and hedging. In fact, every time a liability is not hedged perfectly, the hedging decision is a speculative decision on the outcome of the hedging error. Although hedging and investment problems are often presented separately in the literature, they are indeed two intimately connected aspects of portfolio risk management. A major objective of this book is to take a coherent and pragmatic approach to investment and risk management integrated in a portfolio analysis framework.

The mathematical fields of probability, statistics, and optimization form a natural basis for quantitatively analyzing the consequences of different investment and risk management decisions. However, advanced mathematics is not a necessity per se for dealing with the problems in this area. On the contrary, a large amount of highly sophisticated mathematics in a book on this topic may lead the reader to draw the wrong conclusions about what is essential (and possible) and what is not. We assume that the reader of this book has a mathematical/statistical knowledge corresponding to undergraduate-level courses in linear algebra, analysis, statistics, and probability. Some knowledge of basic optimization theory will also be useful. The book presents material precisely using basic undergraduate-level mathematics and is self-contained.

There are two fundamental difficulties to finding solutions to the problems in investment and risk management. The first is that the decisions strongly depend on subjective probabilities of the future values of financial instruments and other quantities. Financial data are the consequences of human actions and sentiments as well as random events. It is impossible to know the extent to which historical data explain the future that one is trying to model. This is in sharp contrast to card games or roulette where the probability of future outcomes can be considered as known. Statistics may assist the user in motivating the choice of a particular model or to fit models to historical data, but the probabilities of future events will nevertheless be affected by subjective judgment. As a consequence, it is practically impossible to assess the accuracy of the subjective probabilities that go into the mathematical procedures. Misspecifications of the input to a quantitative procedure for decision making will always be reflected in the output, and critical judgment cannot be replaced by mathematical sophistication.

The second fundamental difficulty is that even when there is a consensus on the probabilities of future events, a decision that is optimal for one decision maker may be far from optimal for another one with a different attitude toward risk. Mathematics can assist in translating a probability distribution and an attitude toward risk and reward into a portfolio choice in a consistent way. However, it is difficult to even partially specify a criterion for a desired trade-off between risk and potential reward in an investment situation. Simple and transparent criteria for financial decision making may be more suitable than more advanced alternatives because they enable the user to fully understand the effects of variations in parameter values and probability distributions. Although designing a quantitative and principle-based approach to financial decision making is by no means easy, the alternatives are often ad hoc and lack transparency.

At this point we emphasize the difference between uncertainty and randomness. Even if we do not know the outcome when throwing a fair six-sided die, we can be rather certain that the probability of each possible outcome is one sixth. However, if we do not know the marking of the die, whether it is symmetric, or the number of sides it has, then we have no clue about the probability distribution generating the outcomes. In particular, uncertainty is closely related to lack of information. Saying that we are unsure about the probability distribution of the future value of an asset does not correspond to assigning a probability distribution with a large variance. Knowing the probability distribution is potentially very valuable since it provides a good basis for taking financial positions that are likely to turn out successful. Conversely, if we are very uncertain about the probability distribution of future values, then we should not take any position at all: we should not play a game that we do not understand. Of course, there is a certain degree of uncertainty in all decision making. If one feels more comfortable with, say, assigning a probability distribution to the difference between two future asset prices rather than to the prices themselves, then clearly it is wiser to take a position on the outcome of the difference of the prices. Intelligent use of statistics, together with a good understanding of whether the data are likely to be representative for future events, may reduce the degree of uncertainty. Techniques from probability theory are useful

for quantifying the probability of future events. Techniques from optimization enable one to find optimal decisions and allocations under the assumption that the input to the optimizing procedure is reliable.

Investment and risk management problems are fundamental problems that cannot be ignored. Since it is difficult or impossible to accurately specify the probability distributions that describe the problems we need to solve, we believe that it is essential to focus on the simplest possible principles, methods, and models that still capture the essential features of the problems. Many of the more technically advanced approaches suffer from spurious sophistication when confronted with the real-world problems they are supposed to handle. We have avoided material that is attractive from a mathematical point of view but does not have a clear methodological purpose and practical utility. Our aim has been to produce a text founded in rigorous mathematics that presents practically relevant principles and methods. The material is accessible to students at the advanced undergraduate or Master's level as well as industry professionals with a quantitative background.

The story we want to tell is not primarily told by the theory we present but rather by the examples. The many examples, covering a diverse set of topics, illustrate how principles, methods, and models can be combined to approach concrete problems and to draw useful conclusions. Many of the examples build upon examples presented earlier in the book and form series of examples on a common theme. We want the more extensive examples to be used together with implementations of the methods to address hedging and investment problems with real data. The source code, in the statistical programming language R, that was used to generate the examples and illustrations in the book is publicly available at the authors' Web pages. We have also included exercises that, on the one hand, train the reader in mastering certain techniques and, on the other hand, convey essential ideas. In addition, we have included more demanding projects that assist the reader in obtaining a deeper understanding of the subject matter.

This book is the result of the joint efforts of two academics, Hult and Lindskog, who teamed up with two industry professionals, Hammarlid and Rehn. The material of this book is based on several versions of lecture notes written by Hult and Lindskog for use in courses at KTH. The idea to turn these lecture notes into a book came from Hammarlid and Rehn, and we all underestimated the amount of work required to turn this idea into reality. Essentially all the material from the lecture notes we started off with was either thrown away or rewritten completely. The book was written by Hult and Lindskog but has benefited very much from years of discussions with and valuable feedback from Hammarlid and Rehn. The ordering of the authors reflects the fact that they can be divided into two groups that have contributed differently toward the final result. Within the two groups the authors are simply listed in alphabetic order, and the order there does not have any relevance besides the alphabetical order.

Several people have played an important part in the development of this book. We thank Thomas Mikosch and Sid Resnick for their encouragement and for their valuable feedback on the book. Moreover, their own excellent books have inspired us and provided a goal to aim for. We thank our colleagues Boualem Djehiche and

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