

Preface

Risk and uncertainty are neither topics of recent interest nor a fashion arising due to an increased awareness that uncertainty prevails—fed by information, financial crises, an economy in turmoil, a networked world, and an economic environment increasingly unpredictable. To better mitigate the implications of uncertainty on our life, on our work, on the economy, on our health, and on our environment, we construct risk models. These are models of uncertainty, framing uncertainty in terms of what we know and can predict and provide estimates to their consequences (whether adverse or not). These models are defined using many considerations, predictable factors—some external, some strategic, some based on statistical estimates, some on partial information, some derived from what we actually do, some due to neglect, etc. In these cases, “risk models” seek to construct and define a coherent and practical set of measures, which are analyzed and used to confront objectively and subjectively (based on our values and preferences) the uncertainty we face. These themes underlie also the world of finance.

These elements are common to many disciplines that concern individuals, large and small firms, industries, governments, and societies at large. Industrial risks, strategic (military, economic and competitive) risks, nuclear risks, health and bio-risks, marketing and financial markets risks, environmental risks, contagion risks, etc. are all models of uncertainty with risks defined, measured, assessed, analyzed, and controlled that we seek to value, price, and manage. An interdisciplinary convergence of risk models and their techniques arises due to their common concerns. Various professions have increasingly learned from each other, developing the common means that lead to such a convergence and contributing to the engineering of risks, their management, their valuation, and pricing through contracted exchanges and financial markets. A horizontal risk convergence is prevalent across disparate professions facing similar risk models that contribute to both mutual learning and exchange. For example, statistical controls are applied to control food safety, to health care, to track and audit tax returns, etc. A risk convergence—both horizontal and vertical—has contributed to a greater awareness that risk is no longer a “derivative” or a “consequence” but an integral part of everything we are and we do, what we pay for, and what we seek to profit from.

The commonalities of risks, the need to mitigate, share, transfer, and trade risks, have increasingly contributed to the need for a common valuation of risks, its exchange price, and thereby to the special role of money (and therefore finance) as a common “risk metric.” This book recognizes both the specificity of risks in its many manifestations and, at the same time, the special importance that finance assumes with the growth of financial markets and insurance where “risks of all sorts” are being exchanged.

The many definitions of “Uncertainty”, “Risk” and money can only be covered partially. There is an extraordinarily large number of publications, academic, practical, philosophical, ethical, religious, social, economic, financial, technical (statistical, stochastic models, etc.) that preclude a truly representative coverage. Every aspect of uncertainty and risk models (whether technical or conceptual) is both specific and general at the same time. Setting even its principle elements is overreaching. For this reason, the intent of this book is to provide a partial coverage of elements that seek to bridge theoretical notions of risks and their uses in economics and finance, as well as use examples and applications to highlight their importance.

The book is both narrative and quantitative, outlining a large variety of uncertainty and risk related issues, with examples that emphasize their useful applications. Quantitative techniques particularly based on probability and statistical techniques are both essential to construct risk models and tools to analyze and control risks. Elements of these techniques are presented in this text in three quantitative chapters reviewing basic notions of probability, statistics, and stochastic process modeling. An additional chapter (Chap. 12) is also used to provide an intuitive outline of game theory. These chapters are kept at an introductory level, although some sections require prior studies in applied probability and statistics.

A quantitative formulation is required to both anchor the definition and provide a frame of reference for risk models. The need for quantitative tools in risk analysis and convergence does not negate or reduce the importance for a greater understanding of what is uncertainty, what are risk models, and what are the principles that can reconcile their conceptual meaning and uses in finance. This book, in an attempt to do so, albeit only in a limited sense, focused on many applications and problems. In particular, the book emphasizes the irrevocable interdependence of defining risks, measuring them, and the techniques to assess, to value, to price, and to control financial risks. In some chapters, new approaches to pricing and controlling risks are introduced. These span the development of multi-agents expanded CCAPM pricing model (Consumption Capital Assets Pricing Model) and strategic (game like) statistical controls in the regulation of financial firms.

Although the book emphasizes primarily economic–financial and management problems, other issues and application problems are discussed. In particular, legal issues, health care, and extreme risks are used to emphasize that risk models and techniques, albeit often used in different ways, are in fact quite similar. Chapters 6, 7, 8, 9, and 10 in particular are devoted to the economics, the valuation, and the

price of risk and their models, while Chap. 11 is devoted to risk and strategic risks controls and regulation.

To complement some of the topics covered in the text, an extensive list of references is included in a special section at the end of each chapter, directing the reader to specific references for further applications and study.

In writing this book, I surveyed an extremely large number of papers on fundamental risk theories, some on quantitative risk measurement, valuation, and pricing and some derived risks and papers easily accessible through the Internet. In particular, these papers are accessible through academic services and Web sites such as sciencedirect.com, the SSRN (Social Science research Network), GLORIA (for financial credit risks and derivatives) and Web sites with a special focus in risks of all sorts. I soon realized that there is little one may innovate or add to the extraordinary and accessible explosion of currently published and working papers or to an endless list of econometric and statistical studies outlining educated viewpoints and diffused freely. Yet, I also realized that such an explosion of knowledge is also confusing, difficult to digest, and contains fundamental ideas drowned by information excess. In fact, most of the fundamental theories and applications of risk related papers we mostly refer to are in fact pre-Internet research papers or fundamental theories. This may explain the selection of references used in this book that may seem outdated. It also reinforced my belief that writing books to integrate diffused knowledge is probably more important today than it ever was before. Thus, while I do not believe that this book will add any particular or specific knowledge (except hopefully for some particular and selected problems in risk valuation and control in chapters 8–11), I hope that it will provide an overview of risk in its multiple manifestations, risk models, and uncertainty and thus lead to a better understanding of what is risk and how we may be able to value, price, and confront its consequences.

“Engineering Risk and Finance” is structured as follows. The first two chapters provide a cursory overview of basic concepts such as risk and uncertainty, risk manifestations across numerous areas. A broad overview of conceptual approaches to risk management is also outlined. There is an extensive literature on risk management in all professions that the reader may wish to consult as well. These two chapters are nontechnical providing some motivation for subsequent and technical chapters. The second part, consisting of Chaps. 3, 4, and 5, are essentially technical, reviewing well-known risk and probability models applied to a variety of risk problems to highlight their usefulness. Probability and statistics are an inherent part of risk models, their analysis, and their control. Further, often “everything we do or wish to do” is defined in terms of probability and statistical notions. An appreciation of what these probabilities mean, how they are defined and used is necessarily important for any text on risk. Chapter 3 covers basic probability models, moments, distributions, and their use in selected risk models. Chapter 4 is concerned with multivariate models emphasizing the fact that many risks occur due to the dependence of multiple factors. Chapter 5 is concerned with stochastic models and risk modeling in an inter-temporal perspective. Quantitative models are always based on the specific assumptions made that underlie the definition of risk events, their probability, their causal processes, and their consequences.

Appreciating these assumptions, both for their usefulness and their implications is an important part of risk engineering.

For some students and readers, these quantitative notions are well known and can therefore be skipped (although examples are used to highlight their usefulness) while for others, these may be a bit difficult, and therefore, some sections are starred to indicate their difficulty.

Chapters 6, 7, 8, and 9 introduce principles and methods for risk measurement (Chap. 6), valuation (Chap. 7), risk economics (Chaps. 8 and 9), and uncertainty economics (Chap. 10 by Oren Tapiero). In Chap. 6, we distinguish between statistical measurements, measurements of value and deviations underlying a great number of risk measures. For example, techniques such as risk detection, using a standard deviation as a proxy to manage risks, etc. are outlined and illustrated through numerous examples. In Chap. 7, we emphasize risk valuation using a plethora of techniques as well as utility theory in setting a foundation to risk economics. At the same time, the basic concepts of complete markets for (risk) assets pricing is introduced. Chapter 8 pursues these developments to value the risk of more complex problems. In particular, the concept of (utility based) CCAPM to price certain assets is extended to include a variety of other situations. The development of this framework (in particular the multi-agents Extended CCAPM, which I have pursued in a number of academic papers) is somewhat new and provides an opportunity to study a great many situations and problems to price risks assets in terms of real policy variables as well as a function of macroeconomic factors. Applications to a variety of problems, are then used to delineate both the usefulness and the limits of such approaches. For example, pricing the exchange between a debtor and a lender, the risk and price of economic inequality, the price of rationing, the price other regulation, and so on. Chapter 9 provides additional applications extending Chap. 8. Chapter 10 introduces an approach to “Uncertainty Economics”. It is based on the Doctoral Dissertation of Oren Tapiero (no coincidence, he is my son). It emphasizes an approach to the incomplete Arrow–Debreu theory of pricing using non-extensiveness, Tsallis (and Boltzmann–Gibbs) Entropy, and Quantum Physics. This chapter may be viewed as providing a quantified approach to “behavioral finance.” Chapter 11 provides an overview of risk and strategic control techniques for regulation. Given the profusion of texts in this area, the chapter merely outlines its principles and focuses on strategic control problems (based on Game Theory models). Some of the examples used are based on an outgrowth of my past papers and books published. In addition, given the practical importance of management approaches such as 6 Sigma in industrial risk management, robust decision making and experimental design, queue network risks, and their control, these problems are also introduced because of their importance for risk management. The essential contribution of this chapter, however, is in its formulating and solving several problems of regulation statistical control. Particular cases are developed providing a theoretical framework to assess the efficiency and the implications of regulation controls, on both the regulated and the regulator. Again, references are added in the text for the motivated reader.

Chapter 12 provides finally a partial overview of risk games or strategic risks. Such games are important when consequences depend as well on parties' decisions reflecting their information, their preferences, and agendas. Such risks occur in environmental problems, in supply chains, in competitive economic and financial markets, in contracts negotiations, in cyber-risks, etc. In fact, increasingly, risks have become strategic. It is, therefore, essential that techniques that conceptualize these special characteristics be addressed. In this sense, Chap. 12 is partly an appendix to strategic issues considered in a number of chapters.

This book is intended as a background text for undergraduate and graduate courses in Risk Finance, in Risk Engineering and Management, as well as a book intended for professionals that are both concerned and experienced in some aspect of risk assessment and management techniques. Given the book's finance and interdisciplinary approach, it differs from functional books in these areas in its attempt to view risk as representing common issues faced by many disciplines. As a result, an appreciation of uncertainty and risk, what it means, how they differ, their manifestations, and how to value and manage both uncertainty and risk models are perceived as generic problems relevant to industry, to business, to health care, to finance, etc. Professional readers, aside from financial managers, and financial and risk engineers may, therefore, (hopefully) find some elements in this book to be useful or find another approach to risk and uncertainty which is based on "money valuation" which they may have not been aware of.

Of course, experience and approaches to risks and their management have been devised by numerous professions, resulting from risk technology transfers between these professions and finance. The intent of this book is to capitalize on this "technology transfer." All disciplines concerned by risks and how they define and confront it have contributed an enormous and overbearing number of books, academic papers, and general publications. While the number of papers and books I consulted was extremely large, it is possible that some ideas and some results were reproduced by neglect or due to my being unaware of the appropriate reference. I apologize if this is the case. I have borrowed heavily from articles I have published over the past years as well as new results resulting from my own research and my many collaborative papers. Of course, I would like to express my gratitude to all the collaborators I had over the years and from whom and from each I have learned much.

Finally, I have profited from discussions, comments, and help from many students, colleagues, and friends. Although they are many, I wish to thank my colleagues, Nassim Taleb, Alain Bensoussan, Elizabeth Pathe-Cornell, Pierre Vallois, Raphael Douady, Mirela Ivan, Konstantin Kogan, Oren Tapiero, Mina Teicher, Bertrand Munier, Agnes Tourin, Fred Novomestky, my children Daniel, Dafna, and Oren—all of whom are concerned with risks, financial and global, my students, Jin QiuZZi, Yijia Long, Ge Yan, and so many others from whom I have learned much. I also wish to thank the Sloan Foundation, and in particular Prof. Dan Goroff for the support and encouragement they have provided.

Not least, I am also thanking my partner Carole, who had the patience to tolerate the endless frustrations to have this book finished.

Finally, I wish to dedicate this book to my mother, Violette Budestchu Tapiero, whose love and care while alive nourished me and all my family.

Brooklyn, NY, USA

Charles S. Tapiero

Engineering Risk and Finance

Tapiero, C.S.

2013, XVIII, 508 p. 41 illus., 30 illus. in color.,

ISBN: 978-1-4614-6234-7