Understanding Financial Risk Management

Second Edition

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INVESTOR IN PEOPLE

To the one and only:

Margherita

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Contents

List of Tables

List of Figures

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About the Author

Angelo Corelli is Associate Professor of Finance at the American University in Dubai. His field of expertise is financial risk management with a focus on credit risk. Angelo's research topics span from quantitative risk management to term structure analysis and valuation/risk of financial derivatives. The main focus of his teaching lies on corporate finance, with a special emphasis on corporate valuation mechanisms.

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Preface to the First Edition

A Modern Approach

Understanding Financial Risk Management offers an innovative approach to financial risk management. With a broad view of theory and the industry, it aims at being a friendly, but serious, starting point for those who encounter risk management for the first time, as well as for more advanced users.

The focus is no longer on the mere measurement, but on the whole package. Risk is also opportunity, and when managing it, one should reach the right balance between opportunity and loss. That is why we propose a new approach that starts from the basic knowledge of classic theory and methodologies and moves to the latest findings in measurement and hedging.

Many books are more exhaustive in covering some of the topics that are treated in this book, but most of them do not offer the wholesome coverage on the horizon of financial risk management as the present book does.

There is no doubt that a deeper analysis of many concepts is possible, but no book in the actual market is able to collect all risks and the managing of them in one single essay. This book is definitely an all-included piece or work that guides the reader from the beginning to the end without ever losing focus on what is more important for good risk-management knowledge.

An Innovative Pedagogy

The foundations of the book rely on three main blocks: theory, analytics, and computational. They all merge in a way that makes it easy for students to understand the exact meaning of the concepts and their representation and applicability in real world contexts. Examples are given throughout the chapters in order to clarify the most intricate aspects; where needed, there are appendices at the end of chapters that give more mathematical insights about specific topics.

Learning comes from the correct combination of the three pillar elements, none of which should be excluded. The trinity stands as the foundation of the whole project.

Preferably, students have a solid background in financial mathematics, statistics, and basic econometrics. Indeed, students facing financial topics for the first time may benefit from using the book as a medium-level introduction to some aspects of financial theory and practice.

In this sense, practitioners represent a possible share of the users of the book. In recent years, due to the global financial crisis, the demand for links between academics and private industry has increased substantially. For this reason, practitioners nowadays

like to explore the work done in academic research, and this book provides useful information for managers who want to increase their knowledge about risk management and understand what may have been the lacking in their own systems.

A Selected Audience

The book is meant for third- or fourth-year undergraduate students of business finance, quantitative finance, and financial mathematics. Most of the universities that the book would target offer the kind of training in mathematics and statistics that would be prerequisites for the successful completion of a course using *Understanding Financial Risk Management*. Potential users include students of universities, technical schools, and business schools offering courses in financial risk management.

This book offers a unique approach and represents a clear improvement on existing textbooks in the field of finance. Most textbooks on financial risk management focus on measurement or on some specific kind of risk. There is no challenge or criticism in them, and there is no drive for understanding risk management in the critical sense. That is exactly what this book will offer.

Quantitative approaches now incorporate a more critical view and contribute to a vision that does not blindly rely on numbers, but takes into account the variety of (sometimes unpredictable) situations that characterize financial markets.

Certainly, it is not an easy book, but it is a book that never abandons the reader. Even in the most complicated parts, the student is guided through the processes and given the tools he needs; nothing is cryptic.

A Reliable Partner for Instructors

Understanding Risk Management is tailored mostly for in-class lectures, and it has the best effect if combined with good quality lecture slides from the instructor. Secondarily, given its overall flexibility (a result of its simple structure), it can also be used for online learning. However, the medium-high level of difficulty of the book suggests the need for a closer relation with the instructor and the possibility of in-person explanations.

The structure of *Understanding Financial Risk Management* lends itself to a typical Swedish course of approximately six ECTS. The 10 chapters, of at most 60 pages each, can fit a course design of about 14–16 lectures of 1.5 hours effective teaching. That would also fit an overall international standard of a course with two lectures per week spanned over a two-month teaching term. The overall contents in the book can fill approximately 40–60 hours of teaching.

Richness in Content

This book is the ultimate tool for understanding the many aspects of financial risk management, and it comes with a solid theoretical set.

This first edition has been edited to help educators around the world, suiting users dealing with financial risk for the first time, as well as more advanced users looking for an innovative approach.

As a textbook, the richness in content, exercises, and applications makes the book the perfect partner for the students of all areas in the world, all shaped in a book featuring:

(a) 14 chapters,
(b) 70 major and 126 detailed learning outcomes,
(c) numerous tasks (questions and exercises),
(d) snapshots and appendices wherever relevant, and
(e) numerous selected references.

Every chapter follows the same structure, where the full text is complemented by snapshots relating to cutting-edge research and up-to-date news. At the end of each chapter, there is an exercise section with targeted tasks.

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Preface to the Second Edition

The second edition of *Understanding Financial Risk Management* aims to improve the first edition by introducing a more structured approach to the sources of risk in the organization, and the methods used to manage it.

From identification to assessment and management, all types of financial risks a company faces daily are analyzed, together with the tools and techniques that can be used to limit their impact and manage their connected risk events.

Built on the solid pedagogical approach used in the first edition, the second edition improves it by extending the narrative to modern and innovative topics like enterprise risk.

The result is a 20-chapter textbook that takes the student into a full-immersion experience. After an introductory part where distributional issues, statistical tools, and other foundation topics are analyzed, the chapters start digging deep into all types of financial risk that are normally presented to the organization on a daily basis.

An improved coverage of major risks, together with ample narrative on how to use financial derivatives to hedge risk, offer a complete view on past, current, and future trends in financial risk management.

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Chapter 1
Risk: An Overview

Financial markets are typically characterized by transparent pricing and specific trading regulations. The costs, fees, and market forces determine the price of traded securities, and the risk embedded in any single trade.

Risk can be defined as the possibility of negative outcome as a consequence of specific choices. In all fields of life, including business and financial activities, actions that lead to a loss can be defined as risk. Various types of risk daily affect a business; but when it comes to money, they can be mainly classified into two types: business risk and financial risk.

Financial risk in particular involves the financial structure of the corporation. It generally arises by variability of prices and returns on financial markets. Movements can involve any kind of security as stocks, currencies, derivatives, and interest rates.

Financial risk managers have the duty to perform identification, measurement, and hedging of risk, if necessary. Financial instruments can be used for the purpose but it is not always necessary to do that, since often risk entails the opportunity of a good expected return in exchange.

It is not possible to prevent all possible risks, given some of them are unpredictable and not identifiable sufficiently in advance. However, for many types of risk, the analytical, computational, and numerical tools available in the literature can offer a way of reducing uncertainty.

After studying this chapter, you will be able to answer the following questions, among others:

(1) What is financial risk and how does it differ from other types of risk?
(2) What are the various types of financial risk and how do they link to each other?
(3) What are the differences among risk in banks, corporation, and insurances?
(4) How can we define the process of risk management, and what steps does it involve?
(5) What are the most common types of strategies and instruments involved in risk management?

The first section of the chapter is an introduction to the definition of risk, and how it arises in different types of business. The second section is about the various types of financial risk and their interconnection. The final part aims at introducing the process of risk management, as identification, measurement, and mitigation and/or transfer.

1.1. Introduction

Learning Outcomes

(1) Distinguish between uncertainty and risk.
(2) Learn about generic concepts in utility theory.
(3) Acquire generic knowledge about different types of risk.

1.1.1. Randomness and Uncertainty

Financial risk management has its roots in the history of commercial and financial trades, but it is still a modern quantitative discipline. Its development began during the 1970s, on the premises of the first Basel Accord, between the G10 countries, which covered the regulation of banking risk.

Modern financial markets are constantly subject to speculative attacks and external shocks, given the uncertainty of the actual worldwide economic environment. Financial risk management is therefore in a state of confusion, and gained focus, in recent years, on the minimization of capital charges and corporate risk.

Managing risk is about making decisions under uncertainty, with decisions involving a large share of investors, and determining the outcome of investing strategies for even bigger investors, like banks.

It is now clear that old-fashioned financial risk management has contributed in generating the most severe financial crisis the world ever experienced, due to common use of static risk measurement methodologies and unrestrictive regulatory provisions. As a consequence of the lack in regulation and modeling efficiency, the policies of banks and financial institutions have fed the bubble until it burst, with the effects of the explosion spreading all over the world.

The subprime mortgage affair in US turned quite fast into a global crisis, involving all sectors of the financial and real economy. At some point, it was clear that something was wrong in how risk assessment of new assets had been managed until then.

One of the first definitions of the difference between uncertainty and risk was given by Knight, in 1921. He argued that uncertainty differs from risk for the important reason that risk can be measured precisely.

This difference also plays a crucial role in financial markets, given that, if risk were the only relevant feature of randomness, it could have been possible for financial institutions properly equipped, to price and market insurance contracts based on risky phenomena only. The role of uncertainty is to create frictions that cannot be easily accommodated.

Uncertainty then refers to the situation where an event has an unknown probability, and individuals tend to choose gambles with precise expected outcome, compared to gambles with unknown odds.

Both uncertainty and risk define a random environment and affect individuals and their choices. The behavior of individual agents is often counterintuitive, if confronted to the classic expected utility model, and research has focused on that aspect.

Based on the fact that, if uncertainty is so influential on individual behavior, an equilibrium outcome should exist, Knight claims that, as oppose as risk, uncertainty cannot be insured.

The presence of uncertainty causes departure from standard utility theory and sets an environment where insurance markets may break down, while the randomness of probabilities does not allow for precise pricing of risky claims.

Randomness drives risk and uncertainty, and the two concepts are strictly linked to each other but with some differences. Risk entails the existence of a measurable probability associated to the event.

Probabilities are calculated directly or by induction, depending on the availability of observable variables. Calculation by induction is made via analytical models or by analysis of the past information.

In few words, risk is a quantifiable variable, while uncertainty is not. This is the main distinction between risk and uncertainty. The purpose of financial analysis is to assess risk based on available information.

When a choice must be made, both uncertainty and risk apply. In financial literature, most of the work has been done on risk, given its calculability. It is anyway not appropriate to fully ignore uncertainty.

Example 1.1: Consider two portfolios traded on a market. The first portfolio, A, is a risk-free investment on government bonds, while the second portfolio, B, includes risky complex securities written on a market index. If the expected return on portfolio A is 2.5%, and the expected return on portfolio B is 9.5%, that means investors are demanding an extra 7% to move their money from a risk-free investment to a risky investment.

The concept of risk spans on different disciplines from insurance and engineering to classical economic theories like portfolio theory. Each discipline defines risk in a different way. Some of these definitions are in terms of:

(a) Probability and consequences: This definition of risk focuses on the likelihood of an event to happen and the consequences of the event. Both aspects are involved in ranking the risk-level of an event. Consider for example a tsunami: it has a very small probability of happening, but when happening, it will carry severe consequences. Therefore, it would be ranked as a high-risk event.
(b) Risk or threat: There is a difference between a threat and a risk. Threat is considered to be a very low probability event with extremely large negative outcomes and no possibility for analysts to assess the probability of that event to happen. Risk on the other hand is similar, but it involves events happening at a higher probability, where it is possible to assess both probability and outcome.
(c) Positive and negative outcome: Definitions of risk may involve both positive and negative variability around the mean, or just focus on the downside

scenarios. A fair definition of risk in this sense is the product of probability of an event occurring and the assessed value of the outcome. In the following chapters, it will be clear how this is the main definition of risk underlying the financial analysis.

To be more specific, in finance risk is defined as the (positive or negative) variability of financial returns on some type of investment, around some expected (mean) return. It is then fundamental to understand how to define risk broadly, in order to include both positive and negative side of the variability.

The general rule of thumb is that there is a direct link between risk and reward. High levels of positive outcome can be obtained only getting exposed to considerably large risk. The principle is that there is no free lunch in life, and especially in finance. In fact, the link between risk and return is a foundation of classical and modern finance theory.

In the following chapters, this concept will come very clear. Just for now, it is preliminary important to consider, as an example the difference between investing on financial markets. Stocks are much more risky than bonds, and give a higher expected return.

The concept can be extended to all aspects of life. Therefore, for any business the key to success is the reliability of decision on what types of risk is worth to take, and how much of it.

Protecting the business against all the risk, in some sense, results in limiting the profit opportunities. On the other hand, being exposed to the wrong type of risk can lead to even worse scenarios.

That is why a crucial part of good business management is about making the right choices on how to face different types of risk. Good risk management is a crucial part of good corporate management.

A typical example of risk and uncertainty in finance is the classical portfolio problem. Consider an agent endowed with a wealth of amount w, to invest. The market is very simple, being composed of a risk-free asset paying a fixed rate r and a risky asset with random return x. The random return is distributed according to a cumulative density function, $F(x)$. The utility function of the investor u is assumed to be concave (this is very important for the existence of a risk measure, as it will become clearer in the next paragraphs).

The total wealth is invested by the individual, by dividing it between an amount m of the risky asset, and an amount $w-m$ in the risk-free asset. Therefore, the resulting portfolio value is given by the combination of the stochastic return on the risky asset, and the deterministic return on the risk-free asset, and can be written as

$$p = mx + (w-m)r$$

The problem of asset allocation, among the assets in the market, entails an optimization program, which maximizes the expected utility from the investment strategy as described.

The investor maximizes the portfolio value given the utility function, and the program is defined as

$$\max \int u\big[mx+(w-m)r\big]dF(x)$$

The first-order condition for the program is

$$\int u'\big[m(x-r)+wr\big](x-r)dF(x)=0$$

If the investor is risk neutral, there is no need of compensation for the risk taken, and the resulting utility function is linear and directly proportional to the value of the risky asset, in the form

$$u(x)=\lambda x$$

where
λ is some constant.

This makes the marginal return on the investment is given by the sum of returns on both the risk-free and the risky part of the investment.

$$r_M=\lambda r(w-m)+\lambda mE(x)$$

where
$E(x)$ is the expected return on the risky asset, which is equivalent to

$$r_M=\lambda wr+\lambda m\big[E(x)-r\big] \tag{1.1}$$

Equation (1.1) shows that returns are always positive if $E(x)>r$ and always negative otherwise. The logical consequence is that a risk-neutral investor will always invest all the wealth in the asset with highest expected return.

Given this result, the concavity of the utility function also implies that the marginal return given by investing a bit more in the risky asset is always positive. This is a very important result, implying that also a risk-averse investor will choose to not put all the wealth on just the risk-free asset.

All types of investors will always choose to put at lease a small bit of their wealth on the risky assets. In terms of insurance, this means that a risk-adverse agent will never choose to buy full insurance, unless insurance prices are equal or below the fair actuarial level, where the fair actuarial price is the price corresponding to a zero net present value.

1.1.2. Rationality and Risk Aversion

The theory of rational expectations is a foundation of modern economics and finance. It includes assumptions on how the investors (agents) process the available information to form their expectations.

There are some firm points in the theory of rationality and information, which is scarce on the markets, so that it is important to keep track of the relevant knowledge. Investors form their expectations in a way that depends on the structure of the economic system, and the information history embedded in market prices.

In finance, the outcome of many situations depends on the expectations of investors. Often prices depend on the trading decision of the investors, which in turn depend on how the investors behave on the market.

People tend to rush in selling and buying assets, following the predictions they have on the market price. Financial markets tend to adjust very quickly to new information and investors must be quick in implementing their strategies.

There is a two-way flow of influences between expectations and outcomes, so that people try to make forecasts of what will occur, and base their expectations on that.

Better forecast mean better profits.

Investors adjust their expectation and the way they interpret the information is highly dependent on the past outcome of the process. They adapt the forecasting rules to previous errors, to eliminate them.

Rational expectations theory states that outcomes do not differ from people prediction, when these are based on rational processing of the universally available information. Singularly taken, the investors can make mistakes, but the various sides of the market will adjust rapidly and those mistakes will not be persistent.

The theory is based on the assumption that people behave in order to maximize their utility and this belief is the core of a theory that tries to predict future outcomes of an economic system, based on past decisions of the agents.

Rational expectations are at the basis of many theories, like the random walk theory of financial assets, the efficient market hypothesis, economic theories of consumption, public economic policies, and so on.

The efficient market hypothesis applies rational expectations to efficient markets and asset pricing. It concludes that, after adjusting for discounting and dividends, the changes in a stock price follow a random walk process.

The main bug in classical consumer choice theory is that all the results are drawn in a framework of certainty. However, as mentioned above, real world is characterized by uncertainty, so that bad things may happen, and agents must adapt to it.

Investors make choices in a context of uncertainty and the outcomes are often unpredictable. But there is a need to look forward, and make predictions somehow. In order to get a realistic model of choice, it is necessary to model uncertainty.

A standard gamble has the following expected payoff:

$$E(x) = p_+ x_+ + (1 - p_+) x_-$$

where
p_+ is the probability of a positive outcome

x_+ is the positive outcome
x_- is the negative outcome.

If asked about entering a fair gamble with positive payoff, most people behave in such a way that they would reject a gamble even if it has an expected positive payoff, when the uncertain prospects are worth less in utility terms than certain ones, even when expected tangible payoffs are the same.

Example 1.2: Assume you are offered a fair gamble. A coin is tossed with a positive payoff (win) of €1,000 if it is head and a negative payoff (loss) of €850 if it is tails. The expected value is

$$E(x) = 0.5 \times 1{,}000 - 0.5 \times 850 = €75$$

A positive value suggests the gamble is worth to be accepted. However, the downside potential loss is so consistent, compared to the winning amount, that most people would reject the gamble.

In order to characterize mathematically the utility maximization framework, leading to the definition of risk and risk measurement, define a world with $1,2,...,n$ possible states associated to probabilities $p_i = p_1, p_2, ..., p_n$. The expected value is defined as

$$E(x) = \sum_{i=1}^{n} p_i x_i$$

Dispersion (variance) is measured as

$$\text{Var}(x) = \sum_{i=1}^{n} p_i \left(x_i - E(x)\right)^2$$

Example 1.3: A stock has a 25% probability, in one year, of being worth €400 and a 75% probability of being worth €200. The expected value is

$$E(x) = 0.25 \times 400 + 0.75 \times 200 = €250$$

and the variance is

$$\text{Var}(x) = 0.25 \times (400 - 250)^2 + 0.75 \times (200 - 250)^2 = 7{,}500$$

By the standard theory of utility, a utility function on the real domain $U|_{\mathbb{R}}$ has an expected utility form if it is possible to assign values $u_1, u_2, ..., u_n$ to the outcomes of a simple lottery. The expected value of the lottery is then given by

$$E(x) = \sum_{i=1}^{n} p_i u_i$$

where
p_i is the probability of outcome i in the simple lottery.

Consider also the compound lottery defined as $(l_1, l_2, ..., l_J; \pi_1, \pi_2, ..., \pi_J)$ being the set yielding the lottery l_j with probability π_j. A utility function has the expected utility form if and only if

$$u\left(\sum_{j=1}^{J} \pi_j l_j\right) = \sum_{j=1}^{J} \pi_j u\left(l_j\right)$$

The shape of the utility function determines the different relationships between expected outcomes and the utility they give. In particular, for a lottery with n outcomes, the main distinction is between the expected value of the utility, defined as

$$E\left[u(x)\right] = \sum_{i=1}^{n} p_i u\left(x_i\right)$$

and the utility of the expected outcome, which is given by

$$u\left[E(x)\right] = u\left(\sum_{i=1}^{n} p_i x_i\right)$$

The risk premium involved in the choice is defined as the difference between the wealth after entering the gamble, and the certain amount.

Example 1.4: Suppose an investor with an initial wealth $w = €100$ and utility function $U(w) = \sqrt{w}$. The risk premium associated to a gamble with 50% probability to get to a wealth of €120 and 50% of lowering the wealth to €80, is given by calculating the expected utility first, as

$$E\left[u(w)\right] = 0.5\sqrt{120} + 0.5\sqrt{80} = 9.95$$

Since $u(w) = \sqrt{w} \Rightarrow w = \left[u(w)\right]^2$, the wealth associated with it is given by

$$w = 9.95^2 = €98.99$$

And the risk premium is given by

$$\text{RP} = 100 - 98.99 = €1.01$$

The relationship between the expected utility and the utility of the expectation determines the risk attitude of the investors. It turns out that if

$$E\left[u(x)\right] = u\left[E(x)\right]$$

where
$u(.)$ is a concave utility function.

The investor is risk neutral, if

$$E\left[u(x)\right] > u\left[E(x)\right]$$