Financial Economics

Antonio Mele

Università della Svizzera Italiana, Swiss Finance Institute, and
Centre for Economic Policy Research

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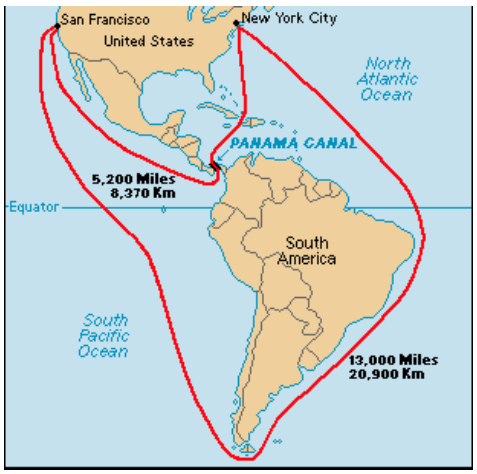

Front cover explanations

Top: Illustration of the increased efficiency in maritime routing allowed by the Suez Canal (right panel) opened in 1869, and the Panama Canal (left panel) opened in 1913, two amongst the most enduring technological marvels with global economic and political implications.

Bottom: A 75 year 3% coupon bearing bond issued by the Panama Canal Company ("Compagnie Universelle du Canal Interocéanique de Panama") in October 1884. The company defaulted in 1889 under the leadership of the Count Ferdinand de Lesseps, who during 1858 had also founded the Suez Canal Company ("Compagnie Universelle du Canal Maritime de Suez").

Information about the author

Antonio Mele is a Professor of Finance at Università della Svizzera Italiana in Lugano and holds a Senior Chair at the Swiss Finance Institute, after a decade spent as a tenured faculty at the London School of Economics. He is also a Research Fellow for the Financial Economics program at the Centre for Economic Policy Research (CEPR) in London. He holds a PhD in Economics from the University of Paris and a BSc in Economics from LUISS University in Rome. His work spans a variety of fields in financial economics, including information in securities markets, financial markets and the macroeconomy, uncertainty and volatility in financial markets, interest rates and credit markets and, finally, econometrics and numerical methods in finance. His research has been published in journals such as the *Journal of Financial Economics*, the *Review of Economic Studies,* the *Review of Financial Studies*, and the *Journal of Monetary Economics*. He authored or co-authored three books on themes regarding financial market volatility.

His work outside academia has led to real-time indicators of uncertainty in fixed income markets that have been adopted by Chicago Board Options Exchange (Cboe) and S&P Dow Jones Indices and instruments to hedge volatility of interest rates and credit spreads. He is the co-inventor of the first volatility indices and related tradable instruments operated through an exchange, designed to standardize and simplify interest rate volatility trading much in the spirit of the Cboe VIX index in the equity space. He also acted as a member of the *Securities and Markets Stakeholder Group* of the European Securities Markets Authority (ESMA), the supra-national supervisor of European financial markets.

Contents

Introduction

A. A brief description of the book

This book originates from a set of notes I wrote in support of graduate and advanced undergraduate lectures in financial economics, macroeconomic dynamics, financial econometrics and financial engineering. These notes have circulated for about 20 years under the title *Lectures on Financial Economics*. Unifying these notes into a coherent book was tantamount to engage into a long and patient journey into historical intellectual developments as well as the interactions of ideas and theories with actual markets behaviors. The book attempts at a "synthesis" of the state of knowledge accumulated during 70 years of initially intermittent but, later, incessant contributions to this very important field of economics.[1]

Finance has the potential to oil the wheels of the real economy. While economists still debate about the benefits of finance for our society, more than a dozen of scholars researching into this field may be counted as Nobel Memorial Prize laureates in Economic Sciences. Progress was sometimes faster than any attempts at organizing our thoughts. Initially, efforts at synthesis were focussing on the mathematical structures of the pioneering work underlying the foundations of finance. Later, synthesis became more problematic as research work had proliferated through such disparate domains including, among others, the evaluation of derivatives instruments, the behavior of markets over the business cycle, information problems in corporate finance and asset markets and, last but not least, the then nascent econometrics of financial markets. The initial "classics" would often cover non-overlapping spaces, as reviewed in Section C of this Introduction. We are still struggling with the creation of a comprehensive treatment of financial economics. This book is an attempt at such a treatment, an attempt at linking various theories and ideas to empirical puzzles and, sometimes, established market practice.

Financial economics relies on sophisticated methods that have already received a comprehensive textbook treatment, since at least the early classics. While this book still aims at providing foundations and methodology, it is intended as a narrative of the historic milestones in the progress of thought. Empirical puzzles have motivated the emergence of new explanations of

[1] In fact, a century of contributions, once we account for those portions of this book dealing with markets plagued by Knightian uncertainty (Keynes, 1921; Knight, 1921) and those market failures identified by Keynes (1936). In Section B of this Introduction, I review the early contribution of Bachelier (1900).

financial market behaviors and, then, new foundations; likewise, new theories have prompted for additional testable predictions. This virtuous interaction has led to immense knowledge that I try to account for while trying to connect various areas in a single piece. I would have liked to write a "history of financial economics," but, as noted, I only attempt at a synthesis of as much as I can. Section B of this Introduction provides motivation and historical perspective regarding the progress of knowledge that occurred during the last many decades, and a broad outline of the book.

Writing an account on the state of knowledge in financial economics is a significant challenge. I may count more than 200 models underlying the explanations in this book. Does model uncertainty disqualify financial economics from being a science? I am writing this Introduction with a humble but decisively optimistic view, even though underlying this view is the acknowledgment that we are dealing with such a large and sometimes fragmented field, and still far from being unified. But while we cannot rely on controlled experiments as in other fields, our models lead to predictions that are typically testable through the availability of myriads of data. I hope that this book will make the reader comfortable with the idea that financial economics is progressing on a well-defined path, that the two-hundred models I discuss belong to a common paradigm and, finally, that each of these models is very important, by shedding light into specific angles of the varied and complex structure of financial markets. This project has the potential to produce a durable impact once these learning objectives are met.

B. Overview and coverage

This book aims to track the milestones achieved in the history of thought in financial economics. Its objective is to provide a comprehensive reference while attempting at organizing about a century of work, while relying on a rigorous analytical framework and, finally, while providing methodological tools that try to make it self-contained. At the same time, the book endeavors to help explain real phenomena and how these phenomena and, sometimes, market practice, have helped economists reformulate previous theories. Furthermore, the book includes many examples and solved problems that illustrate the main lessons conveyed by the models analyzed in the book. I don't provide supplementary material such as solutions, answers or other material to accompany the book. The book tries to be self-contained. Likewise, all problems and analytical examples that illustrate theories, methods or empirical regularities are not at end of each chapter; rather, they are presented right where I (probably mistakenly) thought it would have been appropriate.

While our field is very large, the present work tries to cover as much as I can, while maintaining a balance between theoretical explanations and empirical evidence and identifying the practical relevance of our knowledge. The outcome might still appear to be patchy—again, a reflection of the nature of our field, but also of my limited abilities. However, I hope that I am managing to provide the reader with a coherent treatment of many disparate aspects of financial markets, those arising in idealized explanations (be they based on abstract or empirical methodologies), those that are most relevant to the market practice and, finally, those that may be of interest to scholars working in related fields.

The book is organized in three parts: (I) Foundations, (II) Empirical lessons and market inefficiencies, and (III) Asset pricing and reality.

"Part I: Foundations" develops primordial tools of analysis while striving to keep track of historical backgrounds. For example, Chapter 1 deals with portfolio selection problems arising in the early 1950s and the initial theories of asset prices of the 1960s, works that are understood to be at the origins of financial economics. The next chapters in this Part provide refinements of the initial theories, based on subsequent breakthroughs made to understand the role of asset prices in the general equilibrium of economies subject to uncertainty, in both static (Chapter 2) and dynamic settings (Chapters 3 and 4), and in markets with information frictions (Chapter 5). Historically, the apex of these developments was reached with the advent of "continuous time finance" and its methods occurring during the 1970s. Continuous time models would elegantly address difficult problems including no-arbitrage pricing of redundant securities (derivatives, in some cases), or portfolio choices through dynamic programming. The "martingale methods" of the 1980s-1990s would seal this toolbox with additional instruments, but they also paved the way to the analysis of incomplete markets and other market imperfections. It is the "golden age" of financial theory, a famous expression proposed by Darrell Duffie in his classic *Dynamic Asset Pricing Theory* (2001, p. xiii).

This Part covers details of this progress but it also provides perspective into its economic significance. The goal of this book is to understand financial market fluctuations and, sometimes, the behavior of firms subject to financial constraints, or the role that these fluctuations and behaviors play in conveying information and resources back to society. Information asymmetries and market imperfections are actually a recurrent theme in this book. Thus, Chapters 1 through 3 deal with the idealized markets leading to the initial explanations of asset prices; for example, Chapter 3 deals with financial markets while attempting at taking a broad perspective, one in which finance is part of a general ecosystem; however, our discussions in this chapter (often, not always) rely on models without frictions. In these markets, asset prices relate to consumption, production, money, and the links arise through the behavior of fully rational individuals. Next, Chapter 4 shows the beauties of continuous time finance applied to classical problems such as no-arbitrage pricing or portfolio selection (relying on dynamic programming), but also incomplete markets or the theory of irreversible investments and real options. In a real option problem, decisions are triggered when some underlying signals reach some values. For example, one may decide to exercise an American option only when the underlying asset price hits some level. Likewise, a firm subject to cash constraints may decide to distribute dividends only when its reserves are sufficiently large. Finally, some investors subject to short-sell constraints may wish to sell the securities they hold only when the underlying fundamentals reach a certain threshold. These frictions are, then, dealt with in more detail in other chapters (see, e.g., the liquidity and capital structure problems analyzed in Chapters 5 and 14 (Part III); or how, in Chapter 9 (Part II), real option theory may help explain bubble formation in markets subject to short-sell constraints).

Chapter 5 explains some famous conceptual difficulties in defining a general equilibrium. These issues exist due to asymmetric information, and potentially lead to question the very existence of markets or the process of securities creation. Indeed, information problems have always been valuable sources of inspiration for economists. More in detail, Chapter 5 does rely on these information problems and provides the reader with an overview of theories of financial contracting and theories of capital structure. According to classical irrelevance results, capital structure does not affect the value of a firm. Why do, then, corporations issue debt or equity, i.e., financial assets that may subsequently trade on secondary markets? Or, suppose that a firm receives funds to undertake a project; shouldn't then the same firm lose some of its initial motivation in undertaking the necessary care while handling the project? How to incentivize

this firm's manager to exert the efforts that would make his interests aligned to those of the investors? What is a firm's dividend distribution policy in the presence of liquidity constraints? Can we understand a firm capital structure while making reference to theories of dynamic contracts? The chapter often relies on powerful tools in real option theory to illustrate theories of recursive contracts in continuous time.

Some theories are important because of their main qualitative conclusions, and it may not be needed to test for their "functional form." But financial economics is also a field that lends itself so naturally to vast empirical investigations, especially in contexts in which models may predict different outcomes according to parameter values. We need to assess the statistical relevance of certain theories and, even more fundamentally, we need to estimate a model to be used by decision makers, be they policy makers or private corporations. Chapter 6 deals with theories and methods of statistical inference needed to deal with models arising in financial economics, relying on classical econometric tools such as maximum likelihood, methods of moments, and the relatively more modern simulation-based inference methods.

The purpose of *"Part II: Empirical lessons and market inefficiencies"* is to explain the main empirical facts and the challenges that these facts pose to financial economists. The first puzzles regard excess price volatility, that is, the difficulty of the early dynamic models to explain aggregate market behavior. According to the early models, market volatility (and the premium required by investors to invest in a volatile environment) is one order of magnitude less than that we observe in the markets. Chapter 7 is an introduction to these critical problems and in particular to their measurement methods. These methods were developed mainly during the 1980s-1990s and, in part, the 2000s, and are obviously statistical in nature. At the same time, they rely on the principle of no-arbitrage: there are many ways we can price assets while only requiring absence of arbitrage; however, there is a benchmark amongst these ways, solely relying on securities market data, which we can use to assess whether a model under scrutiny implies implausible parameter values (such as, say, the investors' risk appetite).

To address the volatility puzzles, financial economists added explanations of financial market behavior based on a variety of assumptions: investors' attitude to risk-taking (e.g., non-expected utility, or habit formation), idiosyncratic risk, incomplete markets or restricted market participation, heterogeneous beliefs, learning in markets with incomplete information, a fully specified production sector, or Knightian and model uncertainty. This progress was based on the foundational work made during the "golden age" of financial theory described in Part I. It occurred in the 2000s-2010s and is described in Chapters 8 and 9. Interestingly, these new models address relatively older issues; for example, they predict that, under conditions, the aggregate equity premium and stock market volatility are both countercyclical, a fact known from earlier empirical research. But while these models were developed, financial economists also realized that they could explain additional "cross-sectional anomalies" such as the value premium (the tendency for firms with low multiples to perform better in the future than those with high), or the hoary issue of predictability (the tendency of the market to reverse its trends after a while, maybe in tandem with the business cycle).

A common trait of these models is their adoption of the "separation hypothesis," that is, the assumption that the real economy is not affected by financial market developments. Perhaps due to the dramatic counterfactual evidence brought about by the Great Recession of the late 2000s, a new research agenda relaxed this assumption, aiming to revitalize previous work made by macroeconomists on "financial accelerator" mechanisms: the power of financial markets to exacerbate business cycles through feedback effects. Not only, then, financial markets reflect

the fundamentals of the economy. The real economy is also affected by conditions in financial markets; to illustrate, business is more difficult to get financed when collateral values (financial assets, for example) for potential loans deteriorate, which occurs precisely in bad times. Thus, financial markets may act as accelerators of adverse economic conditions. Integrating financial markets into the real sphere of the economy is the explicit intellectual acknowledgment of the crucial role that financial markets (frictions) play in society. Chapter 9 contains many links to this literature, and some of these links form the basis for additional discussions and formal analysis in various junctures of Part III.

Chapter 10 concludes this Part while pointing to other famous puzzles and frictions. Do financial markets provide useful information? How deep "price discovery" is, that is, how well asset prices reflect the fundamentals in a world with heterogenous information? This chapter begins with the classical analysis of markets plagued with information problems. Investors obviously have different pieces of information, and some of them are even known to possess superior information. A "lemon problem" arises: what are the incentives to trade with better informed investors? One answer is that trading may only arise when markets are somehow (informationally) inefficient: when information is not available symmetrically in the marketplace, we can only trade once we know that our would-be trading counterparty is not necessarily better informed than us. One implication of this reasoning is that agents with less information would never be able to reverse-engineer the information of better informed traders from the price; but this inefficiency (a price that is only partially revealing) may actually be what makes markets function.

For longtime, this price inefficiency has been modeled as a result of the presence of exogenous liquidity shocks. In fact, liquidity and information problems have long been understood as the two sides of the same coin. But liquidity is not only information, and this chapter describes alternative explanations for it. Remarkably, these information and related problems were tackled while, at the same time, economists were in the process of developing market microstructure theory, i.e., the theory of price formation in trading venues relatively more realistic than those hypothesized during the golden age. However, financial markets and trading venues can be even much more complex than the literature had initially hypothesized: Chapter 10 explains that the presence of irrational traders, information networks, limits of arbitrage, segmented markets, or decentralized trading systems (e.g., over-the-counter markets), were all exciting topics of research from the 1990s through the 2010s, which still promise to improve our understanding of such a complex phenomenon as the price formation process. Chapter 10 also contains surveys of topics regarding coordination failures and higher-order beliefs in financial markets. Why do bank crises arise? What are the determinants of a bank-run? What makes agents coordinate to equilibrium outcomes where prices can deviate from fundamentals, as in the famous beauty contests introduced by John Maynard Keynes in his *General Theory of Employment, Interest and Money* (1936, chapter 12)? Remember, in these contests, the winners are those who pick up the most popular faces from many photographs and, thus, are incentivized to forecast the forecasts of others, and everyone is doing the same thing. How do higher order beliefs affect price dynamics?

"Part III: Asset pricing and reality" aims to bring to fruition the lessons drawn from Part II and cope (through the main analytical tools in Part I) with the main challenges posed by actual financial markets, such as those arising from option pricing and trading, interest rate modeling, or credit risk and the associated derivatives. In a sense, Part II is about the big puzzles we face

in fundamental research, while Part III is about how to live within our current and certainly unsatisfactory paradigms, so as to cope with demand for intellectual expertise.

The importance of these topics can never be emphasized enough. Investments or business cycles are clouded with uncertainty. While investing, decision makers put their jobs and the security of their families at risk, thereby affecting human capital accumulation and, hence, the life of future generations. Sometimes, the effects of poorly informed choices can be devastating. The 2007-subprime crisis and the subsequent Great Recession certainly illustrate these mechanisms. In general, financial market volatility is huge, for one reason or another, illustrated by the theories and facts in Part II. It is, thus, a naturally human response to try and find a solution to cope with these risks.

Derivative securities are instruments to insure against risks related to certain investment decisions. As is well known, they are called "derivatives" because their value is drawn from that of other securities. For example, if we are long a number of shares, we may wish to purchase put options on these shares (or on a dedicated index of them), which pay off when the shares' value is down; intuitively, then, the price of these options decreases with the price of the underlying securities. Louis Bachelier's *Théorie de la spéculation* in 1900 is the first attempt at tackling these evaluation problems—problems that were tackled again during the golden age, based on no-arbitrage principles.

At the heart of this principle lie different assumptions, and one of them dictates that the underlying securities (or, in general, risks) should be well understood by all market participants. For example, the shares underlying the previous options should be traded in reasonably liquid markets, a condition for price discovery. It is most likely the case with many derivative securities such as the equity index options or the U.S. Treasury derivatives that are traded in well functioning Exchanges, but also with a variety of derivatives traded in over-the-counter markets (e.g., interest rate swaps or credit related products). However, if risks are poorly understood and price discovery is scarce, derivatives may be mispriced. A case of "toxicity" may then arise: investors may inadvertently add too high doses of complex derivatives in their portfolios than justified by their risk-return trade-off profile. Unfortunately, financial history shows many cases of toxicity. The last chapter of Part III examines some details of one of them, related to the process of securitization of very risky mortgages.

Engineering can be defined as a set of processes and methods that attempt to use established scientific knowledge to solve practical problems, as with the case of steam engines utilized during the first Industrial Revolution. In fact, if it wasn't for the previous mishaps, it would have been very tempting to title this Part *"Financial engineering."* Instead, "Asset pricing and reality" reminds us that while our engines do certainly rely on scientific and rigorous knowledge, this knowledge seems to be more limited than in the domains of the physical sciences. It does not mean that financial economists are not in the process of building up financial engineering. Nor does it mean that financial innovation is unnecessary or toxic. We shall learn throughout the whole book that financial innovation may allow for risk-sharing (the transfer of some risks from those who are not willing to bear them to those who are) when the pre-existing markets are not diverse enough (i.e., incomplete). In fact, and interestingly, not only are financial economists inspired by the events they see (as with the previous revival of the financial accelerator hypothesis motivated by the Great Recession); sometimes, they lead to institutional changes: option markets would most probably not exist today without the golden age revolution of the 1970s.

Yet our most successful inventions regard risks that can at least be identified. Some of these inventions attract liquidity, which, in turn, generates price discovery and, then, liquidity again,

over a virtuous circle. Liquidity begets liquidity: a product is more likely to trade if a trader knows he could easily trade it when, in the future, he will decide to get out from his current trade. Financial products are a little bit like a fax machine was at the time of its introduction: they are worth because others are willing to use them. Potential market makers and financial economists alike (see Chapter 10) are well aware of this chicken-and-egg problem: coordination may fail even when risks are well identified. The exposition in this Part is affected by a sort of survivorship bias: it regards products, trading methods and processes that have been successful. The exception is the description of *some* credit related products at the epicenter of the 2007-2009 crisis.

Chapter 11 illustrates well the scope of Part III: while Part II describes theories and facts regarding asset market volatility, this chapter analyzes ways investors may trade it in the equity space. The technicalities can be actually complex: we have realized volatility, stochastic volatility, implied volatility and volatility surfaces, implied binomial trees and local volatility. Some models can be useful to buy-side institutions; others to sell-side firms that are only interested in pure intermediation activities. Furthermore, and somehow unexpectedly, the theory of financial derivatives witnessed to important developments during the 1990s and the 2000s. These developments regarded new definitions of volatility and new instruments and contracts to trade this volatility, known as "variance swaps." A variance swap enables a counterparty exposed to equity markets to experience a constant volatility within a given horizon. Remarkably, and under conditions, this contract can be evaluated in a model-free fashion, i.e., without any strong assumptions except absence of arbitrage. The fair value of these contracts was suggestive of new indicators of uncertainty and volatility in equity markets, known as VIX. New instruments were, then, introduced and referenced to VIX. It is another episode of financial history when theory had preceded market practice. Note that trading volatility enables us to mitigate uncertainty, but has the potential to contribute to new avenues to systemic risk that policy-makers and regulators alike should need to be very well aware of. This section, then, reviews such avenues within the broader context of feedback effects: certain trading strategies are procyclical, in that they specify to sell into a falling market and to buy in a rising market. The nature of these strategies resembles the accelerator mechanisms in Chapter 9 (Part II): agents react to signals in a way that makes these signals persist. The result is a notion of endogenous market volatility, which, in some cases, may take the extreme form of a market crash. The chapter reviews some of these crashes and analyzes the mechanisms behind them.

Chapter 12 and Chapter 13 repeat some of these analyses in the more sophisticated field that is fixed income. Fixed income securities are complex due to theoretical reasons (they track the time value of money), technical reasons (they have multiple dimensions, such as expiration or tenors of the various contracts) and, last but not least, because price discovery in these markets may be somehow hindered by their trading mechanisms (over-the-counter markets). Yet fixed income securities allow pension funds and other asset managers to mitigate interest rate risk, which can be much, much higher than equity market risk. Interest rates do also display some important business cycle properties, which policy-makers rely on while trying to predict the business cycle: for this reason, Chapter 13 contains some links to a number of fascinating topics also arising in macroeconomics. Finally, Chapter 14 deals with the evaluation of debt subject to default risk, derivatives based thereon and methods to monitor both credit and systemic risk. While this chapter is focussed on practical aspects, it also contains a few junctures devoted to the analysis of strategic default (by both firms and governments), the origins of the 2007-subprime crisis and discussions of feedback effects of the type analyzed in Chapter 9 (Part II) and Chapter 11.

Engineering can be civil or electronic engineering, amongst many others. Likewise, a would-be "financial engineering" field should not be only about derivatives and interest rates. For example, it should also deal with such issues as portfolio optimization in the presence of short-sale constraints, time-varying volatility (ARCH models, for example), Bayesian learning, variance shrinkage methods, and with many additional topics that would make a very long list. In general, this field should be a chameleon, just as it happens in the physical sciences: it should take the colors of the specific set of problems that is helping to address, in order to facilitate financial transactions, information processes (including, for instance, the design of volatility indices with data stemming out from over-the-counter markets) and methods both in the buy-side and sell-side worlds. Some of these topics are covered throughout the book although their systematic treatment goes well beyond the scope of this work.

C. Discussion of related work

Financial economics has evolved while crossing a variety of boundaries. How did we track this progress? Ingersoll (1987), Huang and Litzenberger (1988) and Duffie (2001) are the first classics organizing more than thirty years of conceptual analysis, while O'Hara (1995) is the first classic organizing the theories of the 1980s on liquidity and market microstructure.

These works led to a sophisticated and consistent framework at the basis of subsequent progress, progress that occurred mostly in response to empirical challenges faced by the initial analyses; for example, during the mid 1990s and the early 2000s, new models were proposed to explain how aggregate market behavior links to the business cycle. Cochrane (2005), Back (2010) and Campbell (2017) provided further momentum to standardization of knowledge, teaching how part of this progress relates to the initial analyses. The early work of Campbell, Lo and MacKinlay (1997) offered a quite exhaustive overview of many statistical instruments that are still of paramount importance in the empirical modeling or statistical testing of financial markets phenomena.

Foucault, Pagano and Röell (2013) summarized further progress related to studies of market liquidity and microstructure. During the 2000s, Amaro de Matos (2001) and Tirole (2006) provided us with the first attempts at organizing knowledge acquired in the theory of corporate finance, while during the 1990s, Freixas and Rochet (1997) had already written a classic in the theory of banking. In the references section of this Introduction, I list additional references on works that attempt at organizing knowledge in financial economics.

I like to represent this book as being complementary to these very important works. The added value of mine is to provide general perspective into a large variety of topics, as well as details of the historical progress leading to our current understanding of each of these topics.

To illustrate, the Handbooks of the Economics of Finance (Constantinides, Harris and Stultz, 2003, 2013) currently undertake the ambitious task of dealing with many disparate topics arising in financial economics. However, these works are contributed by several authors and they are only partially coordinated. This book provides explicit linkages across chapters, which may help a reader interested in learning or reviewing several topics while accessing to a common language. For example, the book may be used as a reference in several courses in advanced training programs: adopting this book for a single course (e.g., a course in macro-finance) should allow the reader to access material for related courses (one in financial markets with frictions, say) while relying on a style that he or she is already familiar with. But the most remarkable feature of the efforts I have tried to accomplish in this book is the ambition to cover

a wide range of topics, the milestones in the history of thought in this field, while maintaining a balance across theory, empirical evidence, historical contexts and, also, market practice. As explained, in the references section of this Introduction, I would like to bring a few additional textbook treatments of the field to the reader's attention, noting that these represent my own preferred readings, and apologizing with all omitted authors.

D. Audience and pre-requisites

The main audience for this book will be academics studying, teaching and researching in financial economics. The book also aims to appeal to applied researchers and other professionals servicing investment banks, institutional investors, central banks and governments. The inclusion of policy makers as part of the audience for this book is motivated by the widespread acknowledgment of the many interconnections between financial markets and the macroeconomy. Macro-financial linkages arising through the business cycle (or, say, market liquidity, microstructure and volatility) are themes that have motivated important work by financial economists; this work is very useful reading for those engaged in designing supervisory standards and macroprudential policies. The main audience for this book will be financial economists, though. I shall return to additional factors explaining potential audience in Section E below.

The style of the book is eminently academic. It is primarily quantitative, even while, on many occasions, the book provides descriptions of markets and historical contexts. But appreciating this book in its entirety relies on a predisposition to quantitative reasoning. At the same time, quantitative reasoning is the means, not the goal of this work. Thus, in general, appreciating this book also requires to be genuinely passionate about economics. Finally, the book is suitable to both theorists and empiricists or fellows searching for concrete applications. Applied researchers will have access to a clear theoretical background needed prior to undertaking meaningful empirical research. Theorists will learn the nature of the empirical regularities and puzzles that have characterized our field since its very beginnings, knowledge that is indispensable prior to undertaking meaningful theoretical research.

Reading the book requires knowledge of economics and mathematics at a level required from a candidate to a Master of Science in Finance and Economics at the London School of Economics or to a PhD in Finance at the Swiss Finance Institute, two programs where I delivered many of the lectures inspiring this work. I also believe that the book may be accessed by a well-motivated student enrolled into a program such as, say, a Bachelor of Science in Economics and Statistics at University College London. Therefore, reading this book requires maturity in both microeconomics and macroeconomics at the level of Varian (1992) and Blanchard (2017) textbooks, respectively. Moreover, some readers might already have gained motivation for finance while exposed to introductory finance textbooks such as Berk and DeMarzo (2016) and Bodie, Kane and Marcus (2014). Additional pre-requisites include knowledge of calculus, basic knowledge of time series and statistics, and an introductory exposure to stochastic calculus. Many technicalities are introduced and explained in appropriate junctures of the book, along with references to more advanced material.

E. Usage of the book

The reader of this book is a scholar in financial economics, a market practitioner, a policymaker, or a scholar in related fields such as macroeconomics.

A scholar in financial economics may (i) recommend this book to a specialized readership for a survey of work linked to his or her research articles; (ii) recommend portions of the book to advanced graduate or PhD classes as complements to his or her lecture notes; and, finally, (iii) value a book that attempts at a synthesis: for example, reading this book may help a young scholar develop a critical view of our current understanding of financial markets, thereby stimulating further and hopefully important research.

A market practitioner or a policy maker with an appropriate background (see Section D) may find a source of valuable information in this book. For example, certain parts of the book (Part III as well as some chapters in Part II) may provide a quantitative strategist or a risk manager with guidance on elaborating, estimating and implementing models for signal generation. Even more important, the book may help gain intellectual perspective into the many details that arise in market or policy practice.

Finally, a reader of this book may be a scholar in other fields. For example, a macroeconomist might be interested in financial economics from a broad and still rigorous perspective; this book may help shed light into his or her own research and, perhaps, motivate to recommend portions of it to his or her PhD classes. For example, some financial economists grew up by learning from some of the classics described in Section C of this Introduction, while at the same time reading the beautiful *Lectures on Macroeconomics* of Blanchard and Fischer (1989), which helped shape some research into macro-finance. Similarly, one objective of this book is to attract the attention of scholars in other fields. Oftentimes did scholars in other fields make "excursions" into financial economics and provide marvelous contributions, e.g., on the role of information in securities markets, idiosyncratic risk or financial accelerator mechanisms. I hope that the general perspective I endeavor to follow in this book may attract scholars from other fields and help render such excursions more frequent.

The book contains material that may be accessed to while learning about a number of topics, and/or be used as a reference for a number of courses, such as:

- Foundations of portfolio selection (Chapter 1)
- Foundations of financial economics (selected portions of Chapters 2, 3, 4, 5 and 10)
- Introduction to quantitative methods in finance (selected portions of Chapters 3; Chapter 4)
- Statistical methods of financial model validation (Chapters 6 and 7)
- Financial markets and the macroeconomy (Chapters 8 and 9)
- Information and financial markets (Chapters 5 and 10)
- Financial markets, debt and frictions (Chapters 5 and 10, and selected portions of Chapters 9 and 14)
- Option pricing and volatility trading (Chapter 11)
- Fixed income markets and derivatives (Chapters 12 and 13)
- Credit markets and derivatives (Chapter 14)
- Derivatives and financial engineering (selected portions of Chapters 11 through 14)

The chapters indicated in parenthesis contain the relevant material for the suggested courses, which I have indeed been experimenting for the last 20 years or so.

F. Acknowledgments and disclaimers

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Antonio Mele
December 2020

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