

C A S E S I N
**FINANCIAL
ENGINEERING**

APPLIED STUDIES OF FINANCIAL INNOVATION



SCOTT MASON • ROBERT MERTON
ANDRÉ PEROLD • PETER TUFANO

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**CASES IN FINANCIAL
ENGINEERING:**
**Applied Studies of Financial
Innovation**

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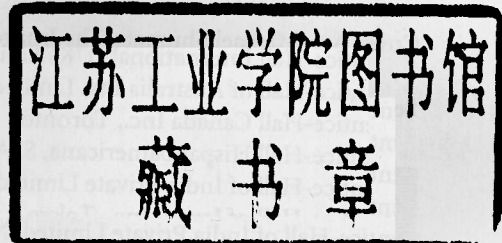
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To *Linda*
June
Suellen
Mary Jeanne

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I NTRODUCTION

Financial innovation is the dynamic force propelling the financial system towards its function of providing more efficient resource allocation in the economy. Innovation benefits society by lowering transaction costs, completing markets, and making prices more informative. Investors, corporations, and financial-service firms realize those benefits in the form of lowered costs of raising funds, enhanced investment returns, more precise management of risk exposures, and greater efficiency in operating under changing tax and regulatory regimes. Financial innovation, broadly defined, includes not only the creation of new types of securities, but also the development and evolution of new financial organizations. Financial engineering embodies many of the skills, techniques, and processes that produce both new securities and new financial organizations. It is the application of advances in related technologies that permit the diagnosis, analysis, design, production, pricing, and customization of solutions to problems in finance. The scope of these technologies encompasses conceptual advances in pricing and hedging that support more comprehensive derivative-securities markets and risk-management systems; improvements in computer speed and capacity that enable systems to securitize assets and monitor thousands of trading positions in real time; and developments in communications systems that facilitate the simultaneous actions needed to exploit transient arbitrage opportunities. Thus, financial engineering can be viewed as the means of implementing financial innovation. Together, financial innovation and engineering have increased the pace and complexity of change in the financial system, providing extensive opportunities for financial engineers as well as for financial managers, corporate executives, public-policy makers, and business educators.

An incorrect, but commonly held, belief is that financial engineering and financial innovation are accessible, or more importantly *relevant*, only to a small group of mathematics students or technical practitioners. The relevance of financial innovation should be measured by its impact on the effectiveness of the financial system, and not by its novelty. Similarly, the power of financial engineering should be defined not by the complexity of its models or computers but by the expanded economic or managerial flexibility it offers to its users. By these measures, financial engineering and financial innovation are relevant to a broad audience. Financial engineers can create and price an uncountable array of financing vehicles for corporations. They can structure instruments to provide risk exposures to almost

any variable that an investment manager might imagine. Financial innovation and engineering give their users a myriad of new alternatives from which they must choose. Thus, financial engineering should be studied *within the context of the managerial or public-policy decisions to which it is applied*, training not only the financial engineers but also those who rely upon these engineers to solve long-standing and vexing problems of corporate finance and investment management. Training in financial engineering is also necessary for those involved in oversight, including public-policy makers whose charge is to safeguard the public interest as well as those who manage the financial-service firms that employ the engineers.

The case studies and notes in *Cases in Financial Engineering* were designed and have been used at the Harvard Business School to introduce thousands of MBA students to financial innovation and financial engineering. This material was developed to reflect the fundamental continuing changes in both the financial system and the finance profession, as well as to meet strong student demand. The case format, along with the opening chapters and notes, allows this book to be used as the primary text for an MBA course for general management students, or as a supplementary text for an advanced course designed for specialists in financial engineering. In both instances, the cases provide rich and exciting contexts for the application of financial-engineering techniques. They cover some recent innovations, as well as older products which were important milestones in the areas of swaps, securitization, interest rate derivatives, municipal bond products, and equity-linked instruments. The cases, combined with the introductory chapters that provide both a conceptual and a historical framework, were designed to highlight a number of themes: the dynamic and persistent nature of financial innovation; a functional perspective that characterizes products by the needs they satisfy; cost factors that stimulate new financial products; exploitation of apparent arbitrage opportunities; and learning and experimentation in financial markets.

Some readers will not be familiar with cases or with their use for more effective teaching. Our experience has been that the case method of instruction is very effective in teaching the concepts, as well as the managerial practicality, of financial engineering. Most cases are highly developed presentations of a business problem or issue requiring action or a decision. The cases in this book underscore to students that complex financial-engineering problems typically exist in even more complex business settings. Careful quantitative analysis is essential but not sufficient as these cases require decisions that must take into account other important business factors besides the successful application of financial modeling. In this important sense, the case method of instruction goes beyond the traditional distinction between *theoretical* and *applied*. It deals fully with the difficulty of making decisions and taking actions in a multi-faceted and changing business environment. For example, a

product such as the Nikkei Put Warrants (described later in this book) offers ample opportunity to demonstrate the application of technical pricing skills. However, the case study of this product not only raises theoretical pricing issues but also forces students to consider competitive dynamics, product design and marketing considerations, and the value of innovation to an investment bank's reputation—all in an environment of incomplete information.

Case presentations and the case method of instruction make financial engineering accessible to a wide range of students. While the theoretical foundations and pure applications of methods and models are of natural interest to technically-inclined students, we have found that a broader pool of students find case studies of financial engineering stimulating, accessible, and interesting. Certainly the emphasis on managerial issues helps explain this response. It is a plain fact that many students believe that it is important to their professional careers to have a working knowledge of financial engineering. We have not sacrificed quantitative rigor to satisfy this objective but have jointly emphasized technique and managerial implications. This is precisely the role served by cases and the case method of instruction.

The sequencing of the cases and notes is not intended to define a path along which these materials should be used in a course; instead, it reflects a set of thematic groupings of the book's material consistent with the ideas developed in the introductory chapters. The two introductory chapters provide a conceptual and a historical framework for understanding financial innovation and financial engineering generally, and the cases specifically. The first chapter discusses the role of financial innovation in the financial system; the logic of considering the financial system, its institutions and products in terms of the functions they deliver, and the financial-innovation spiral, by which one innovation begets others. The second chapter attempts to place the case studies in historical context, by using the case studies in the book, along with innovations from the nineteenth and early twentieth century, to explain how cost considerations, changes in users' demands, and learning have affected the path of financial innovation.

Cases in Financial Engineering can be variously organized for use by advanced undergraduates, MBAs, or doctoral students. In general, students will benefit from a first course in derivative securities, either prior to or at the same time that they are studying these cases. It is also possible to use the case studies in a first course, interweaving technical lessons with the case discussion. The book can also be used in a more advanced course with students who already have training in derivative securities to illustrate and apply the concepts. The material fits in a number of more traditional formats, including courses in capital markets and risk management.

Plans for teaching this book can be organized along at least four dimensions: (i) by the *type of instrument* covered; (ii) the primary *end-user*; (iii) the *underlying security* on which derivatives are written, or (iv) the *rationale* for the innovation. For example, an instructor organizing a course by instrument type might group in one module the cases focusing on options and embedded options; in a second module the cases on forwards, futures, swaps; and in a third, those on securitization. The strength of this approach rests on its focus on technique, such as option-pricing technology. Its weakness is having cases span multiple instrument types, as users consider a variety of alternatives. A second design based on end-users might emphasize cases that primarily address the needs of either corporations, investment managers, or investment banks. This approach allows for focus on the needs of particular users of the financial system, but often the cases must simultaneously address the needs of two or three of these parties at once, or consider a wide range of instruments. A third alternative is to focus on the underlying securities of the derivative instruments studied: e.g., equities, fixed income, commodities. For example, all of the equity-linked products could be discussed in related sessions, allowing students to develop institutional details on particular markets. The fourth approach is to organize the material thematically, by grouping the cases broadly according to the rationale that helps explain why the innovation has been created. The organization of the book attempts to facilitate this approach by identifying a number of uses to which financial engineering has been put: exploiting arbitrage opportunities, resolving information asymmetries, optimizing with respect to the tax and regulatory environment, and managing risk. This approach is consistent with the central theme voiced in the first chapter: the most fruitful examination of complicated financial products, activities, or systems will flow from a careful consideration of the financial functions that they serve.

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Scott P. Mason

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CHAPTER 1

FINANCIAL INNOVATION AND THE FINANCIAL SYSTEM

INTRODUCTION

The core function of the financial system is to facilitate the allocation and deployment of economic resources, both spatially and across time, in an uncertain environment. This system consists of the capital markets as well as the basic payment system through which virtually all transactions clear. In today's well-developed economies, capital markets include the money, fixed-income, and equity markets, as well as the new and growing markets for "derivative" securities such as futures and options. Capital market functions are also performed by financial intermediaries such as banks and insurance companies that provide more customized products and services—the kind that do not lend themselves to the standardization necessary to create a liquid market.

The capital markets make possible the basic cash-flow cycle in which household savings are channeled into capital investments by firms and then returned to households (via security repurchases, dividends, and interest payments) for consumption and recycling as new savings. The capital markets provide risk-pooling and risk-sharing opportunities for both households and business firms. These markets also serve an important function as a key source of information that helps coordinate decentralized decision-making in various sectors of the international economy.

In this chapter, financial innovation is viewed as the central mechanism pushing the financial system toward its goal of improving performance of what economists call the "real economy." The chapter begins with an assessment of the causes and consequences of the wave of recent innovations and then uses that assessment as a basis for discussing the motivations for innovation as well as its social value.

This chapter is largely a consolidation of portions of Merton (1992a; 1993), with the permission of the *Journal of Applied Corporate Finance* and the Economic Council, respectively.

The chapter continues with a focus on the core functions of the financial system. Innovations that only redistribute wealth and perhaps affect regulatory changes but do not improve the efficiency by which the financial system serves those functions will not significantly affect long-run economic efficiency. Hence, the effectiveness of financial innovation with respect to economic performance is better studied from a “functional” perspective rather than an “institutional” one.

Financial intermediation—the process of transforming financial assets from one form into another—is a central activity within all financial systems. Financial engineering is the process of tailoring financial instruments and organizational structure to improve the profitability of intermediaries’ customers. This production process of intermediaries is also the principal means for implementing financial innovation into the system. In this chapter, two polar, prototypical models, “underwriting” and “synthesizing,” are developed; their combinations span the range of intermediary approaches to production exemplified throughout this volume.

The institutional structure that performs the financial functions differs considerably among economies. Furthermore, the current environment of rapid technological changes and movement toward a global financial market will produce significant intertemporal shifts in the institutional structure of a given economy. However, the basic functions of a financial system are essentially the same in all economies—past and present, East and West. Therefore, as demonstrated later in this chapter, a functional approach to analyzing the dynamics of changes in the financial system may provide a more useful organizing perspective than an institutional approach. The chapter closes using functional analysis as a basis for speculating about the future of financial regulation.

FINANCIAL INNOVATION

To make the case that financial innovation over the past 20 years has led to revolutionary changes in the international financial system, one need hardly do more than mention round-the-clock-trading Tokyo-London-New York, financial futures, swaps, mortgage-backed securities, exchange-traded options, “junk” bonds, shelf registration, electronic funds transfer and security trading, automated teller machines, NOW accounts, asset-based financing, LBO, MBO, and all the other acronymic approaches to corporate restructuring. And these are but a small sampling.

Of course, financial innovation has been going on for a considerable time; many of the innovations of the last two decades, although heralded as novel, were not entirely new. Important examples are exchange-traded options, forwards, and futures contracts. The Dojima rice market in Osaka was a forward market in the seventeenth century and a fully

organized futures market by the eighteenth century.¹ Organized futures exchanges were created in Frankfurt in 1867 and in London in 1877. The Chicago Board of Trade was founded in 1848 and the New York Cotton Exchange was incorporated in 1872. Options on commodity futures were traded on the Chicago Board of Trade in the 1920s. In the seventeenth century, options and contracts resembling futures accounted for the bulk of transactions on the Amsterdam stock exchange, which at the time was the financial center of the Western world. Moreover, from the accounts given by one seventeenth-century observer,² it appears that the regulatory concerns raised about those contracts in Amsterdam—in particular, insider trading, manipulation, excessive speculation and price volatility, and default risks—are much the same as those expressed about options and futures trading today. Some things just never change.

While options and futures may not be entirely new, the proliferation of organized trading markets in both equity and fixed-income derivative securities during the past two decades is unprecedented. Development of these standardized markets was absolutely essential for the subsequent creation of a wide range of financial products, many custom-designed to meet selected needs of investors and corporate issuers. One needs go no further than the weekly trade journal *International Financing Review* to verify the profound impact that derivative securities are having on the mainline global financing of both businesses and sovereigns. Concurrently, mainstream financial institutions and pension-fund-plan sponsors have increasingly adopted quantitative techniques, including computerized trading strategies, to help manage their investment portfolios. The composition of both their equity and fixed-income portfolios has become more global. As with issuers, such investor-side changes could not have been implemented without well-functioning derivative security markets. Those changes have been accompanied by an explosion of trading volume in just about every sector of the financial markets. All this everyone knows. The question is, what has this wave of innovation done for economic performance?

THE SOCIAL VALUE OF FINANCIAL INNOVATION

There are some in the academic, financial, and regulatory communities who see much of this alleged innovation as nothing more than a giant fad, driven by institutional investors and corporate issuers with wholly unrealistic expectations of greater expected returns with less risk, and fueled by financial-services firms and organized exchanges that see huge profits from this vast activity. From this viewpoint, pure rent-seekers develop innovations

1 See Schaede (1988).

2 de la Vega (1688). Bernstein (1992, Ch. 11) reports that Aristotle's anecdote about Thales in Book I of *Politics* is perhaps the first recorded mention of a financial option.