WILEY FINANCE

Financial Derivatives

Third Edition

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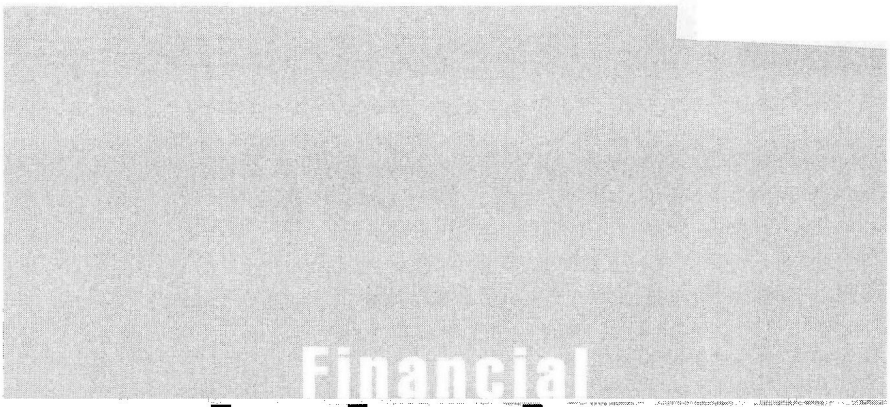
John Wiley & Sons, Inc.

Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
Published simultaneously in Canada.

ISBN 0-471-23232-7

Printed in the United States of America.

10 9 8 7 6 5 4 3 2 1



derivatives

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To my splendid Lori, an original who is anything but derivative.

R.W.K.

To Janis, who is consistently above fair value.

J.A.O.

preface

Financial Derivatives introduces the broad range of markets for financial derivatives. A *financial derivative* is a financial instrument based on another more elementary financial instrument. The value of the financial derivative depends on, or derives from, the more basic instrument. Usually, the base instrument is a cash market financial instrument, such as a bond or a share of stock.

Introductory in nature, this book is designed to supplement a wide range of college and university finance and economics classes. Every effort has been made to reduce the mathematical demands placed on the student, while still developing a broad understanding of trading, pricing, and risk management applications of financial derivatives.

The text has two principal goals. First, the book offers a broad overview of the different types of financial derivatives (futures, options, options on futures, and swaps), while focusing on the principles that determine market prices. These instruments are the basic building blocks of all more complicated risk management positions. Second, the text presents financial derivatives as tools for risk management, not as instruments of speculation. While financial derivatives are unsurpassed as tools for speculation, the book emphasizes the application of financial derivatives as risk management tools in a corporate setting. This approach is consistent with today's emergence of financial institutions and corporations as dominant forces in markets for financial derivatives.

This edition of *Financial Derivatives* includes three new chapters describing the applications of financial derivatives to risk management. These new chapters reflect an increased emphasis on exploring how financial derivatives are applied to managing financial risks. These new chapters—Chapter 3 (Risk Management with Futures Contracts), Chapter 5 (Risk Management with Options Contracts), and Chapter 7 (Risk Management with Swaps)—include several new applied examples. These application chapters follow the chapters describing futures (Chapter 2), options (Chapter 4), and the market swaps (Chapter 6). Chapter 1 (Introduction), surveys the major types of financial derivatives and their basic applications. The chapter discusses three types of financial derivatives—futures, options, and swaps. It then considers

financial engineering—the application of financial derivatives to manage risk. The chapter concludes with a discussion of the markets for financial derivatives and brief comments on the social function of financial derivatives.

Chapter 2 (Futures) explores the futures markets in the United States and the contracts traded on them. Futures markets have a reputation for being incredibly risky. To a large extent, this reputation is justified, but futures contracts may also be used to manage many different kinds of risks. The chapter begins by explaining how a futures exchange is organized and how it helps to promote liquidity to attract greater trading volume. Chapter 2 focuses on the principles of futures pricing. Applications of futures contracts for risk management are explored in Chapter 3.

The second basic type of financial derivative, the option contract, is the subject of Chapter 4 (Options). Options markets are very diverse and have their own particular jargon. As a consequence, understanding options requires a grasp of the institutional details and terminology employed in the market. Chapter 4 begins with a discussion of the institutional background of options markets, including the kinds of contracts traded and the price quotations for various options. However, the chapter focuses principally on the valuation of options. For a potential speculator in options, these pricing relationships are of the greatest importance, as they are for a trader who wants to use options to manage risk.

Applications of options for risk management are explored in Chapter 5. In addition to showing how option contracts can be used in risk management, Chapter 5 shows how the option pricing model can be used to guide risk management decisions. The chapter emphasizes the role of option sensitivity measures (i.e., "The Greeks") in portfolio management.

Compared to futures or options, swap contracts are a recent innovation. A *swap* is an agreement between two parties, called *counterparties,* to exchange sets of cash flows over a period in the future. For example, Party A might agree to pay a fixed rate of interest on $1 million each year for five years to Party B. In return, Party B might pay a floating rate of interest on $1 million each year for five years. The cash flows that the counterparties make are can be tied to the value of debt instruments, to the value of foreign currencies, the value of equities or commodities, or the credit characteristics of a reference asset. This gives rise to five basic kinds of swaps: **interest rate swaps, currency swaps, equity swaps, commodity swaps, and credit swaps.** Chapter 6 (The Swaps Market) provides a basic introduction to the swaps market, a market that has grown incredibly over the last decade. Today, the swaps market has begun to dwarf other derivatives markets, as well as securities markets, including the stock and bond markets. New to this edition's treatment of swaps is a section on counterparty credit risk. Also, applied examples of swaps pricing have been added.

Applications of swaps for risk management are explored in Chapter 7. New to this edition are sections on duration gap management, uses of equity swaps, and swap portfolio management. This last section describes the concepts of value at risk (VaR) and stress testing and their role in managing the risk of a derivatives portfolio.

Chapter 8 (Financial Engineering and Structured Products) shows how forwards, futures, options, and swaps are building blocks that can be combined by the financial engineer to create new instruments that have highly specialized and desirable risk and return characteristics. While the financial engineer cannot create instruments that violate the well–established trade–offs between risk and return, it is possible to develop positions with risk and return profiles that fit a specific situation almost exactly. The chapter also examines some of the high-profile derivatives debacles of the past decade. New to this edition are descriptions of the Metallgesellschaft and Long-Term Capital Management debacles.

As always, in creating a book of this type, authors incur many debts. All of the material in the text has been tested in the classroom and revised in light of that teaching experience. For their patience with different versions of the text, we want to thank our students at the University of Miami and Johns Hopkins University. Shantaram Hegde of the University of Connecticut read the entire text of the first edition and made many useful suggestions. For their work on the previous edition, We would like to thank Kateri Davis, Andrea Coens, and Sandy Schroeder. We would also like to thank the many professors who made suggestions for improving this new edition.

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CHAPTER 1

Introduction

By now the headlines are familiar: "Gibson Greetings Loses $19.7 Million in Derivatives" . . . "Procter and Gamble Takes $157 Million Hit on Derivatives" . . . "Metallgesellschaft Derivatives Losses Put at $1.3 billion" . . . "Derivatives Losses Bankrupt Barings." Such popular press accounts could easily lead us to conclude that derivatives were not only *involved* in these losses, but were *responsible* for them as well. Over the past few years, derivatives have become inviting targets for criticism. They have become demonized—the "D" word—the junk bonds of the New Millennium. But what are they?

Actually, there is not an easy definition. Economists, accountants, lawyers, and government regulators have all struggled to develop a precise definition. Imprecision in the use of the term, moreover, is more than just a semantic problem. It also is a real problem for firms that must operate in a regulatory environment where the meaning of the term often depends on which regulator is using it.

Although there are several competing definitions, we define a *derivative* as a *contract that derives most of its value from some underlying asset, reference rate, or index.* As our definition implies, a derivative must be based on at least one underlying. An *underlying* is the asset, reference rate, or index from which a derivative inherits its principal source of value. Falling within our definition are several different types of derivatives, including commodity derivatives and financial derivatives. A *commodity derivative* is a derivative contract specifying a commodity or commodity index as the underlying. For example, a crude oil forward contract specifies the price, quantity, and date of a future exchange of the grade of crude oil that underlies the forward contract. Because crude oil is a commodity, a crude oil forward contract would be a commodity derivative. A *financial derivative,* the focus of this book, is a derivative contract specifying a financial instrument, interest rate, foreign exchange rate, or financial index as the underlying. For example, a call option on IBM stock gives its owner the right to buy the IBM shares that underlie the option at a predetermined price. In this sense,

an IBM call option derives its value from the value of the underlying shares of IBM stock. Because IBM stock is a financial instrument, the IBM call option is a financial derivative.

In practice, financial derivatives cover a diverse spectrum of underlyings, including stocks, bonds, exchange rates, interest rates, credit characteristics, or stock market indexes. Practically nothing limits the financial instruments, reference rates, or indexes that can serve as the underlying for a financial derivatives contract. Some derivatives, moreover, can be based on more than one underlying. For example, the value of a financial derivative may depend on the difference between a domestic interest rate and a foreign interest rate (i.e., two separate reference rates).

In this chapter, we briefly discuss the major types of financial derivatives and describe some of the ways in which they are used. In succeeding sections, we discuss four types of financial derivatives—forward contracts, futures, options, and swaps. We then turn to a brief consideration of *financial engineering*—the use of financial derivatives, perhaps in combination with standard financial instruments, to create more complex instruments, to solve complex risk management problems, and to exploit arbitrage opportunities. We conclude with a discussion of the markets for financial derivatives and brief comments on their social function.

FORWARD CONTRACTS

The most basic forward contract is a *forward delivery contract.* A forward delivery contract is a contract negotiated between two parties for the delivery of a physical asset (e.g., oil or gold) at a certain time in the future for a certain price fixed at the inception of the contract. The parties that agree to the forward delivery contract are known as *counterparties.* No actual transfer of ownership occurs in the underlying asset when the contract is initiated. Instead, there is simply an agreement to transfer ownership of the underlying asset at some future delivery date. A forward transaction from the perspective of the buyer establishes a *long position* in the underlying commodity. A forward transaction from the perspective of the seller establishes a *short position* in the underlying commodity.

A simple forward delivery contract might specify the exchange of 100 troy ounces of gold one year in the future for a price agreed on today, say $400/oz. If the discounted expected future price of gold in the future is equal to $400/oz. today, the forward contract has no value to either party *ex ante* and thus involves no cash payments at inception. If the *spot price* of gold (i.e., the price for immediate delivery) rises to $450/oz. one year

from now, the purchaser of this contract makes a profit equal to $5,000 ($450 minus $400, times 100 ounces), due entirely to the increase in the price of gold above its initial expected present value. Suppose instead the spot price of gold in a year happened to be $350/oz. Then the purchaser of the forward contract loses $5,000 ($350 minus $400, times 100 ounces), and she would prefer to have bought the gold at the lower spot price at the maturity date.

For the short, every dollar increase in the spot price of gold above the price at which the contract is negotiated causes a $1 per ounce loss on the contract at maturity. Every dollar decline in the spot price of gold yields a $1 per ounce increase in the contract's value at maturity. If the spot price of gold at maturity is exactly $400/oz., the forward seller is no better or worse off than if she had not entered into the contract.

From our example, we can see that the value of the forward contract depends not only on the value of the gold, but also on the creditworthiness of the contract's counterparties. Each counterparty must trust that the other will complete the contract as promised. A default by the losing counterparty means that the winning counterparty will not receive what she is owed under the terms of the contract. The possibility of default is known in advance to both counterparties. Consequently, this kind of forward contract can reasonably take place only between creditworthy counterparties or between counterparties who are willing to mitigate the credit risk they pose by posting collateral or other credit enhancements.

The most notable forward market is the foreign exchange forward market, in which current volume is in excess of one-third of a trillion dollars per day. Forward contracts on physical commodities are also commonly observed. Forward contracts on both foreign exchange and physical commodities involve *physical* settlement at maturity. A contract to purchase Japanese yen for British pounds three months hence, for example, involves a physical transfer of sterling from the buyer to the seller, in return for which the buyer receives yen from the seller at the negotiated exchange rate. Many forward contracts, however, are *cash-settled forward contracts.* At the maturity of such contracts, the long receives a cash payment if the spot price on the underlying prevailing at the contract's maturity date is above the purchase price specified in the contract. If the spot price on the underlying prevailing at the maturity date of the contract is below the purchase price specified in the contract, then the long makes a cash payment.

Forward contracts are important not only because they play an important role as financial instruments in their own right but also because many other financial instruments embodying complex features can be decomposed into various combinations of long and short forward positions.

FUTURES CONTRACTS

A *futures contract* is essentially a forward contract that is traded on an organized financial exchange such as the Chicago Mercantile Exchange (CME).[1] Organized futures markets as we know them arose in the mid-1800s in Chicago. Futures markets began with grains, such as corn, oats, and wheat, as the underlying asset. *Financial futures* are futures contracts based on a financial instrument or financial index. Today, financial futures based on currencies, debt instruments, and financial indexes trade actively. *Foreign currency futures* are futures contracts calling for the delivery of a specific amount of a foreign currency at a specified future date in return for a given payment of U.S. dollars. *Interest rate futures* take a debt instrument, such as a Treasury bill (T-bill) or Treasury bond (T-bond), as their underlying financial instrument. With these kinds of contracts, the trader must deliver a certain kind of debt instrument to fulfill the contract. In addition, some interest rate futures are settled with cash. A popular cash-settled interest rate futures contract is the CME's Eurodollar futures contract, which has a value at expiration based on the difference between 100 and the then-prevailing three-month London Interbank Offer Rate (LIBOR). Eurodollar futures are currently listed with quarterly expiration dates and up to 10 years to maturity. The 10-year deferred contract, for example, has an underlying of the three-month U.S. dollar LIBOR expected to prevail 10 years hence.

Financial futures also trade based on financial indexes. For these kinds of financial futures, there is no delivery, but traders complete their obligations by making cash payments based on changes in the value of the index. *Stock index futures* are futures contracts that are based on the value of an underlying stock index, such as the S&P 500 index. For these futures, movements in the index determine the gains and losses. Rather than attempt to deliver a basket of the 500 stocks in the index, traders settle their accounts by making cash payments that are consistent with movements in the index. Table 1.1 lists the world's major futures exchanges and the types of financial futures that they trade.[2] Financial futures were introduced only in the early 1970s. The first financial futures contracts were for foreign exchange, with interest rate futures beginning to trade in the mid-1970s, followed by stock index futures in the early 1980s.

Most futures transactions in the United States occur through the *open outcry* trading process, in which traders literally "cry out" their bids to go long and offers to go short in a physical trading "pit." This process helps ensure that all traders in a pit have access to the same information about the best available prices. In recent years, there have been several attempts to replicate the trading pit with online computer networks. Replicating the interactions of traders has proven to be a difficult task and computer-based

TABLE 1.1 World Futures Exchanges and the Financial Futures Contracts They Trade

Exchange	FX	IRF	Index
Chicago Board of Trade (USA)	◆	◆	
Chicago Mercantile Exchange (USA)	◆	◆	◆
EUREX (Germany and Switzerland)		◆	◆
London International Financial Futures Exchange (UK)		◆	◆
New York Board of Trade (USA)	◆		◆
Kansas City Board of Trade (USA)			◆
Mid–America Commodity Exchange (USA)	◆		
Bolsa de Mercadorios de Sao Paulo (Brazil)	◆	◆	◆
New York Mercantile Exchange (USA)			◆
London Securities and Derivatives Exchange (UK)			◆
Tokyo International Financial Futures Exchange (Japan)	◆	◆	
Osaka Securities Exchange (Japan)			◆
Tokyo Stock Echange (Japan)		◆	◆
Korea Stock Exchange (South Korea)			◆
Singapore Exchange (Singapore)	◆	◆	◆
Marche a Terme International de France (France)		◆	◆
Hong Kong Futures Exchange (China)	◆	◆	◆
New Zealand Futures Exchange (New Zealand)		◆	◆
Sydney Futures Exchange (Australia)		◆	◆
Montreal Exchange (Canada)		◆	◆
Toronto Futures Exchange (Canada)			◆
OM Stockholm AB (Sweden)		◆	◆
Cantor Financial Futures Exchange (USA)		◆	
BrokerTec Futures Exchange (USA)		◆	

Notes: FX indicates foreign exchange, IRF indicates interest rate futures, and Index indicates any of a variety of indexes, including stock indexes, interest rate indexes, and physical commodity indexes. The New York Board of Trade is the parent company of the Coffee, Sugar, and Cocoa Exchange, the New York Cotton Exchange, FINEX, and the New York Futures Exchange. In addition to the exchanges listed in the table, several other exchanges exist but are not operational.

Sources: Commodity Futures Trading Commission (CFTC), the *Wall Street Journal, Futures Magazine, Intermarket Magazine,* various issues, various exchange publications.

trading has not grown as fast as many industry professionals forecast a decade ago.

FORWARDS VERSUS FUTURES

To say that a futures contract is a forward contract traded on an organized exchange implies more than may be obvious. This is because trading on an organized exchange involves key institutional features aimed at overcoming the biggest problems traders face in using forward contracts: credit risk exposure, the difficulty of searching for trading partners, and the need for an economical means of exiting a position prior to contract termination.

To mitigate credit risk, futures exchanges require periodic recognition of gains and losses. At least daily, futures exchanges mark the value of all futures accounts to current market-determined futures prices. The winners can withdraw any gains in value from the previous mark-to-market period, and those gains are financed by the losses of the "losers" over that period.

Marking to market creates a difference in the way futures and forward contracts allow traders to lock in prices. With a forward contract, the price of the asset exchanged at delivery is simply the price specified in the contract. With a futures contract, the buyer pays and the seller receives the spot price prevailing at the delivery date. If this is so, then how is the price locked in? The answer is that gains and losses on a futures position are recognized daily so that over the life of the futures contract the accumulated profits or losses—coupled with the spot price at delivery—yield a net price corresponding with the futures price quoted at the time the futures position was established. The marking-to-market procedure requires that customers post a performance bond that, loosely speaking, covers the maximum daily loss on their futures position. Those who fail to meet their margin call have their positions liquidated by the exchange before trading resumes. But how does the exchange know what the maximum daily loss is? The answer is that the exchange imposes daily price limits on its contracts (both on the up side and the down side) to define the maximum loss. For example, the New York Mercantile Exchange limits price movements for its nearby crude oil contract to $7.50 per barrel from the previous day's settlement price. If the limit is hit, then trading halts for the day and can resume that day only at prices within the limit. The point is that marking-to-market—coupled with daily price limits—serve to reduce exposure to credit risk.

In addition to marking to market and price limits, futures exchanges use a clearinghouse to serve as the counterparty to all transactions. If two traders consummate a transaction at a particular price, the trade immediately

becomes two legally enforceable contracts: a contract obligating the buyer to buy from the clearinghouse at the negotiated price, and a contract obligating the seller to sell to the clearinghouse at the negotiated price. Individual traders thus never have to engage in credit risk evaluation of other traders. All futures traders face the same credit risk—the risk of a clearinghouse default. To further mitigate credit risk, futures exchanges employ additional means, such as capital requirements, to reduce the probability of clearinghouse default.

A second problem with a forward contract is that the heterogeneity of contract terms makes it difficult to find a trading partner. The terms of forward contracts are customized to suit the individual needs of the counterparties. To agree to a contract, the unique needs of contract counterparties must correspond. For example, a counterparty who wishes to sell gold for delivery in one year, may find it difficult to find someone willing to contract now for the delivery of gold one year from now. Not only must the timing coincide for the two parties, but both parties must want to exchange the same amount of gold. Searching for trading partners under these constraints can be costly and time consuming, leaving many potential traders unable to consummate their desired trades. Organized exchanges, by offering standardized contracts and centralized trading, economize on the cost of searching for trading partners.

A third and related problem with a forward contract is the difficulty in exiting a position, short of actually completing delivery. In the example of the gold forward contract, imagine that one party to the transaction decides after six months that it is undesirable to complete the contract through the delivery process. This trader has only two ways to fulfill his or her obligation. The first way is to make delivery as originally agreed, despite its undesirability. The second is to negotiate with the counterparty, who may in fact be perfectly happy with the original contract terms, to terminate the contract early, a process that typically requires an inducement in the form of a cash payment. As explained in Chapter 2, the existence of organized exchanges makes it easy for traders to complete their obligations without actually making or taking delivery.

Because of credit risk exposure, the cost and difficulty of searching for trading partners, and the need for an economical means of exiting a position early, forward markets have always been restricted in size and scope.[3] Futures markets have emerged to provide an institutional framework that copes with these deficiencies of forward contracts. The organized futures exchange standardizes contract terms and mitigates the credit risk associated with forward contracts. As we will see in Chapter 2, an organized exchange also provides a simple mechanism that allows traders to exit their positions at any time.