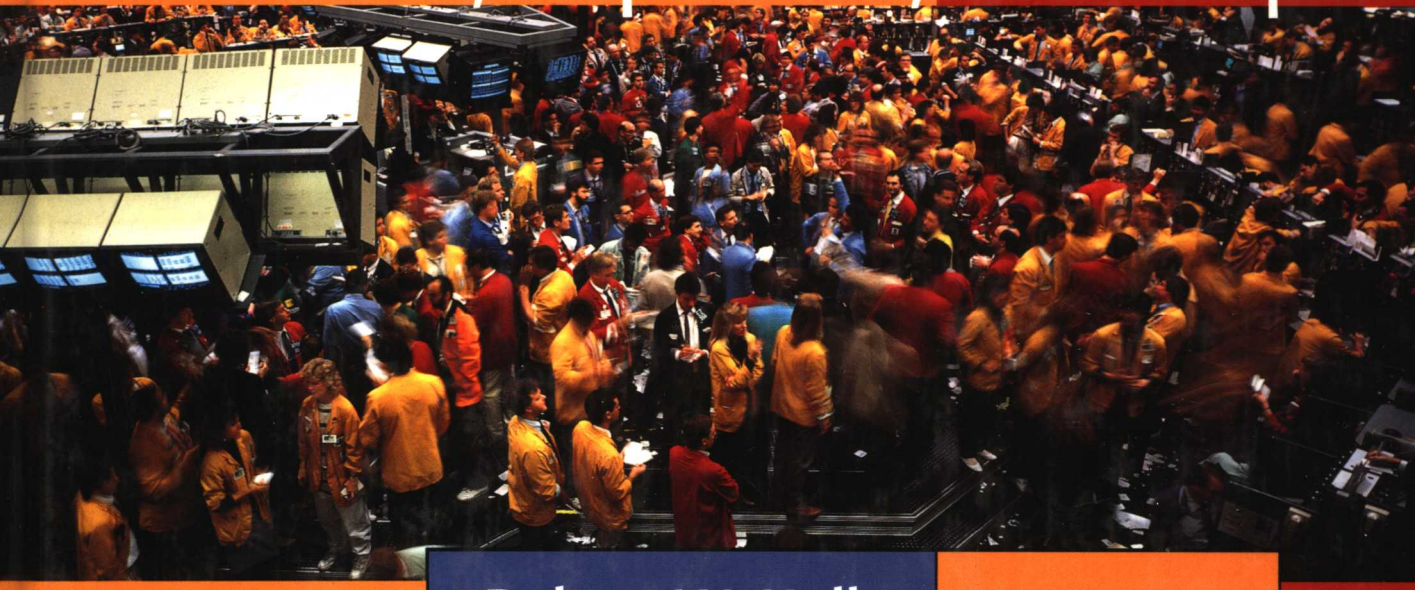
Futures, Options, & Swaps



Robert W. Kolb

THIRD EDITION

BLACKWELL Business

Futures, Options, and Swaps

Third Edition

Robert W. Kolb

First edition published in 1994 by Kolb Publishing.

Second edition published in 1997 by Blackwell Publishers.

Third edition published in 1999 by Blackwell Publishers.

Blackwell Publishers Inc.
350 Main Street
Malden, MA
02148

Blackwell Publishers Ltd.
108 Cowley Road
Oxford OX4 1JF
UK

Library of Congress Cataloging-in-Publication Data

Kolb, Robert W.
Futures, options, and swaps / Robert W. Kolb—3rd ed.
p. cm.
Includes index.
ISBN 0-631-21499-2
1. Derivative securities. 2. Futures. 3. Options (Finance)
4. Swaps (Finance) I. Title.
HG6924.A3K649 1999
332.64'5—dc21 99-12931
CIP

British Library of Congress Cataloging-in-Publication Data

This book is printed on acid-free paper.

Preface

Futures, Options, and Swaps 3e brings together in one text a comprehensive treatment of the three most important types of financial derivatives. These three types of derivatives are linked by a common pricing framework—the proposition that rational prices preclude arbitrage profits. This guiding principle is introduced in the first chapter and pursued throughout the text.

The text also emphasizes the use of futures, options, and swaps in risk management. While the book features ample examples of speculative strategies that can be implemented with these instruments, the focus of the application examples is the management of preexisting risk.

To integrate the understanding of these instruments, the discussion emphasizes the relationships among futures, options, and swaps. For example, various parity conditions are derived and illustrated. As a second example, an interest rate swap is analyzed as a portfolio of bonds, as a portfolio of forward rate agreements, and as a portfolio of futures contracts.

The treatment in this text emphasizes financial derivatives, but it does not neglect traditional commodity futures. From years of teaching this material, I have found that futures can be understood best when the discussion begins with a tangible good having no cash flows, such as gold. Accordingly, the book is organized as follows.

Organization of the Text

Chapter 1, *Introduction,* introduces the key concept of arbitrage that will be used in all subsequent pricing discussions. The chapter also defines and illustrates the various derivatives that will be considered in the text and explains the various uses of these instruments.

Futures

Chapters 2–9 focus on futures markets. Chapter 2, *Futures Markets,* provides an introduction to the institutional framework of the market, including margin, the clearinghouse, and daily settlement. Chapter 3, *Futures Prices,* explores the cost-of-carry model in depth, relating it to the no-arbitrage principle introduced in Chapter 1. Chapter 4, *Using Futures Markets,* discusses the role of speculators in providing market liquidity and in aiding price discovery. Chapter 4 also explores techniques of hedging with futures. Chapters 2–4 provide a comprehensive overview of the market and set the stage for the explicit discussion of financial futures.

Chapters 5–9 consider interest rate futures, stock index futures, and foreign currency futures. Chapter 5, *Interest Rate Futures: Introduction,* and Chapter 6, *Interest Rate Futures: Refinements,* provide detailed coverage of interest rate futures. Chapter 5 introduces the contracts and covers the basic pricing principles, while Chapter 6 explores key issues (such as the features of the T-bond contract and the implicit options in the contract) in more detail. Chapter 6 can be omitted without loss of continuity. Chapter 7, *Stock Index Futures: Introduction,* and Chapter 8, *Stock Index Futures: Refinements,* follow a similar strategy in treating stock index futures. Chapter 9, *Foreign Currency Futures,* discusses the contracts, pricing principles, and applications of foreign exchange futures. It also includes basic material on interest rate parity and purchasing power parity conditions.

Options

Chapters 10–19 cover options in detail. Chapter 10, *The Options Market,* introduces the essential institutional features of the U.S. options market, while Chapter 11, *Option Payoffs and Option Strategies,* begins the analytical treatment of options by exploring popular trading strategies and their payoffs at expiration using familiar no-arbitrage conditions. Chapter 12, *Bounds on Option Prices,* continues to use no-arbitrage arguments to place rational bounds on option prices before expiration.

To specify the exact price that an option should have requires a model of how stock prices can move. Chapter 13, *European Option Pricing,* develops formal pricing models for European options. The price of an option depends on the characteristics of the underlying instrument, notably upon the way in which the price of the underlying instrument can vary. We consider the binomial model and eventually elaborate this model into the Black-Scholes model. Chapter 13 also explores the Merton model. Chapter 14, *Option Sensitivities and Option Hedging,* is a companion to Chapter 13 in that it explores the option sensitivities of the Black-Scholes and Merton models. These sensitivities (DELTA, THETA, VEGA, GAMMA, and RHO) are extremely important in using options to hedge or in controlling the risk of speculative strategies.

Chapter 15, *American Option Pricing,* develops an extensive treatment of American options. It includes coverage of American puts, the exact American call option pricing formula, the analytic approximation approach to pricing American options, and the binomial model as it applies to options with and without dividends. Chapter 16, *Options on Stock Indexes, Foreign Currency, and Futures,* explores stock index options, foreign currency options, and options on futures for both European and American options. Chapter 17, *The Options Approach to Corporate Securities,* shows that the principles of option pricing can be extended to analyze corporate securities. The chapter considers the option features of common stock, straight bonds, convertible bonds, callable bonds, and warrants. One of the most useful features of this chapter is to illustrate the power of the option approach to the world of finance. Chapter 18, *Exotic Options,* details the payoffs for a wide variety of exotic options, presents the valuation formulas, and includes a detailed computational example. Chapter 19, *Interest Rate Options,* is a completely new chapter introduced in the third edition. It focuses on European style interest rate options and emphasizes the Black model for pricing options on LIBOR. As such, Chapter 19 provides an introduction to the fundamentals necessary for understanding the swaps market.

Swaps

Coverage of swaps is contained in Chapters 20–22, which are completely rewritten and vastly expanded since the second edition. Chapter 20, *The Swaps Market: Introduction,* discusses the institutional features of the market, the application of swaps in risk management, and an intuitive approach to pricing. As such, it provides a self-contained introduction to swaps. It also lays the foundation for the detailed treatment in Chapters 21–22. Chapter 21, *Swaps: Economic Analysis and Pricing,* deals with two basic themes. First, the chapter shows how swaps may be analyzed as portfolios of other instruments, such as bonds and forward contracts. Second, the chapter shows how no-arbitrage principles can be used to price interest rate and currency swaps. Chapter 22, *Swaps: Applications,* provides a number of extended, self-contained, and independent application examples for swap risk management and pricing. For example, there is an extended discussion of using interest rate swaps to manage the duration gap of a financial institution.

OPTION! Software

Each copy of the text is accompanied by an IBM PC-compatible program **OPTION!,** which can compute virtually every option and swap value discussed in this book, including a comprehensive module for pricing exotic options. Further, **OPTION!** can graph many of the relationships among different option prices discussed in the chapters that follow. Exploring the option concepts of the text with the software can greatly enhance an understanding of option pricing. Instructions for **OPTION!** are found in an appendix at the end of this text. The text also includes more than 80 exercises designed to enhance the understanding of option pricing principles and applications. These exercises can all be solved using **OPTION!** software. **OPTION!** runs under Windows 98.

What's New in the Third Edition?

There are a number of important changes and enhancements for the third edition:

1. Chapter 19, *Interest Rate Options,* is a completely new chapter for the third edition.
2. The previous modest treatment of swaps has been discarded. In its place, there are three much more extensive chapters devoted to the swaps market, Chapters 20–22. Together, these chapters provide one of the most comprehensive treatments of swaps to be found anywhere.
3. In response to user requests, the end-of-chapter questions and problems have been greatly increased in number, and many more analytical problems have been added to the text.
4. There is now a complete *Solutions Manual* available to the student that includes detailed solutions to all end-of-chapters questions and problems and solutions to all **OPTION!** exercises.
5. The **OPTION!** program has been greatly enhanced. It now operates under Windows 98. In addition, it has a number of new modules covering swap pricing and interest rate options. As such, the program can solve virtually all of the option and swap problems covered in the text.
6. The text now includes selected answers to end-of-chapter questions and problems. Detailed worked-out solutions appear in the *Solutions Manual.*
7. Appendix A to the text provides a brief survey of the new accounting rules for derivatives issued by the Financial Accounting Standard Board (FAS 133) in 1998. Theses rules are the most comprehensive and uniform rules yet implemented for derivatives.

Acknowledgments

This third edition of *Futures, Options, and Swaps* has a long pedigree. It grew out of two earlier texts, *Understanding Futures Markets,* and *Options. Understanding Futures Markets* was first published in the early 1980s and is now in its fifth edition. *Options* came on the scene in the early 1990s and is now in its third edition. Thus, the overwhelming bulk of this material has been extensively classroom-tested in many universities and corporations.

Over all of these editions, I have received the assistance of numerous people, ranging from hundreds of professors to many hundred students. This book has grown out of their contributions and insights, and I am deeply grateful for their efforts. For this edition, I am particularly indebted to the following individuals. John Polonchek and Tom Gosnell of Oklahoma State University provided many new problems and solutions based on their teaching experience. Their contribution enhances the variety and depth of the end-of-chapter exercises and solutions. Don Smith of Boston University, Jeff Buetow of Association for Investment Management and Research, and Bob Johnson of the Association for Investment Management and Research were each instrumental in providing guidance for the major revision and expansion of the swaps materials. Marcelle Arak of the University of Colorado at Denver,

David P. Echevarria of St. Joseph's University, and Thomas William Miller, Jr. of the University of Missouri at Columbia served as academic reviewers. Jay Marchand of Westminster College checked the accuracy of the final typeset manuscript. I would also like to thank L. Ann Martin of the Accounting Department at the University of Colorado in Denver for reviewing Appendix A on the new derivatives accounting rules of FAS 133. Brett Garrett, Ron Dickson, and Larry Becker of Laurel Technical Services did an excellent job in reviewing the manuscript for accuracy, testing each number and computation in hundreds of pages. The OPTION! software has been tested for accuracy and usability by James Overdahl of the Office of the Comptroller of the Currency and by Jay Marchand of Westminster College. Gerry Gay of Georgia State Unviersity and John Polonchek of Oklahoma State University used a pre-release version of the software in their classes and offered helpful comments for improving the program. For the software, I would like to express a special appreciation to Jerry Schneider of 3Com Corporation for revealing to me the mysteries of the Windows 98 registry. In addition, a number of readers suggested corrections and enhancements that helped me to strengthen this edition. I would particularly like to thank Rex Macey, Frank Saldana III, Thomas K. Schmieder, CFA, and Cynthia Zamora, CFA. My profound thanks are due to all of these people for helping me to produce a much better text than I would have been able to produce if left to my own resources. I, of course, bear responsibility for any remaining deficiencies.

As other authors know, the completion of a manuscript is just one way station on the path to a finished book. Many people at Blackwell Publishers have helped to bring this third edition to fruition, and I would like to thank the following people: at Blackwell, Al Bruckner, Executive Editor, Katie Byrne, Development Editor, Lisa McLaughlin, Production Manager, Jean Hammond, Graphic Designer, and at Gustafson Graphics, Sara Dovre Wudali, Production Manager, and Linda Ireland, Copyeditor, for their assistance and expertise in putting this project together.

Beyond dedicating this book to my wife Lori, I wanted to express my additional gratitude and appreciation to her for all of her support, not only as I worked to produce the new edition, but in all dimensions of my life. Absent her love, support, and companionship, my life would be much diminished.

Robert W. Kolb

Contents

1 Introduction

Overview This chapter begins by defining a derivative instrument and distinguishing financial derivatives from derivatives in general. As the word implies, a **derivative instrument** is one whose value depends on the value of something else.

The major derivatives considered in this book are forward contracts, futures contracts, options contracts, options on futures, and swap contracts. This chapter briefly introduces each of these instruments and explains their key features. Later chapters consider each instrument in detail.

After introducing forwards, futures, options, options on futures, and swaps, this chapter gives a brief explanation of why financial derivatives are so critically important in finance today. As we will see throughout this text, these instruments have grown from trivial importance to play a key role in virtually all financial markets. Compared with the fundamental securities on which they are based, financial derivatives afford numerous benefits to both speculators and risk managers. In addition, derivatives offer some surprising advantages in reducing transaction costs and other forms of trading efficiency.

Throughout this text, we will be concerned with the principles that determine the prices of the financial derivatives we consider. The text consistently employs a no-arbitrage principle to illuminate the pricing principles for each instrument. An **arbitrage opportunity** is a chance to make a riskless profit with no investment. In essence, finding an arbitrage opportunity is like finding free money, as we explain in more detail later in this chapter. The **no-arbitrage principle** states that any rational price for a financial instrument must exclude arbitrage opportunities. This is a minimal requirement for a feasible or rational price for any financial instrument. As we will see in detail in the chapters that follow, this no-arbitrage principle is extremely powerful in helping to understand what prices can reasonably prevail for forwards, futures, options, options on futures, and swaps. The chapter then turns to explain how the text is organized.

A computer program called **OPTION!** accompanies this text. **OPTION!** allows the user to compute option prices with ease and provides modules for pricing swaps.

Financial Derivatives

In the financial marketplace, some securities and some instruments are regarded as fundamental, while others are regarded as derivative. In a corporation, for example, the stock and bonds issued by the firm are fundamental securities and form the bedrock of financial geology. Every corporation must have stock, and stock ownership gives rights of ownership to the firm. Owning a bond issued by a firm gives the bondholder the first claim on the firm's cash flows.

In contrast with fundamental securities, such as stocks and bonds, there is an entirely distinct class of financial instruments called derivatives. In finance, a **derivative** is a financial instrument or security whose payoffs depend on a more primitive or fundamental good. For example, a gold futures contract is a derivative instrument, because the value of the futures contract depends upon the value of the gold that underlies the futures contract. The value of the gold is the key, since the value of a gold futures contract derives from the value of the underlying gold.

A **financial derivative** is a financial instrument or security whose payoffs depend on another financial instrument or security. For example, an option on a share of stock depends on the value of the underlying share. Because the underlying good for a stock option is a financial instrument, a stock option is a type of financial derivative. Similarly, a futures contract on a Treasury bond is a financial derivative, because the value of the T-bond futures depends on the value of the underlying Treasury bond.

This book considers four types of financial derivatives: forwards, futures, options, and swaps. In this section, we briefly introduce each instrument and discuss its basic features. Subsequent chapters focus on futures, options, and swaps in detail, while forward contracts are considered in passing throughout the text.

Forwards

A **forward contract,** as it occurs in both forward and futures markets, always involves a contract initiated at one time; performance in accordance with the terms of the contract occurs at a subsequent time. Further, the type of forward contracting to be considered here always involves an exchange of one asset for another. The price at which the exchange occurs is set at the time of the initial contracting. Actual payment and delivery of the good occur later. So defined, almost everyone has engaged in some kind of forward contract.

The following example illustrates a very simple, yet frequently occurring, type of forward contract. Having heard that a highly prized St. Bernard has just given birth to a litter of pups, a dog fancier rushes to the kennel to see the pups. After inspecting the pedigree of the parents, the dog fancier offers to buy a pup from the breeder. The exchange, however, cannot be completed at this time, since the pup is too young to be weaned. The fancier and breeder thus agree that the dog will be delivered in six weeks and that the fancier will pay the $400 in six weeks upon delivery of the puppy. This contract is not a conditional contract; both parties are obligated to complete it as agreed.[1] The puppy example represents a very basic type of forward contract. The example could have been made more complicated by the breeder requiring a deposit, but that would not change the essential character of the transaction.

For example, a foreign currency forward contract calls for the exchange of some quantity of a foreign currency at a future date in exchange for a payment at that later date. At the time of contracting, the forward contract stipulates the price to be paid at the time of delivery of the good. As an example, billions of dollars of foreign currencies change hands daily in a very sophisticated forward market that trades contracts for German marks and English pounds. While forward markets for some goods are highly developed and have standardized market features, a forward contract can be unique, as in the commitment between two individuals to deliver a unique good at a later date in exchange for a price that is established at the time of contracting.

From the simplicity of the contract and its obvious usefulness in resolving uncertainty about the future, it is not surprising that forward contracts have had a very long history. The origin of forward contracting is not clear. Some authors trace the practice to Roman and even classical Greek times. Strong evidence suggests that Roman emperors entered forward contracts to provide the masses with their supply of Egyptian grain. Others have traced the origin of forward contracting to India.[2]

Futures

While the historical origins of forward contracts are obscure, organized futures markets began in Chicago with the opening of the Chicago Board of Trade in 1848.[3] Despite the loss of records in the great Chicago fire of 1871, it appears that futures contracts, as opposed to forward contracts, were being traded on the Board of Trade by the 1860s. Since then, the basic structure of futures contracts has been adopted by a number of other exchanges, both in the United States and abroad.

A **futures contract** is a type of forward contract with highly standardized and closely specified contract terms. As in all forward contracts, a futures contract calls for the exchange of some good at a future date for cash, with the payment for the good to occur at that future date. The purchaser of a futures contract undertakes to receive delivery of the good and pay for it, while the seller of a futures promises to deliver the good and receive payment. The price of the good is determined at the initial time of contracting.

It is important to understand how futures contracts differ from other forms of forward contracts. First, futures contracts always trade on an organized exchange. Second, futures contracts are always highly standardized with a specified quantity of a good, and with a specified delivery date and delivery mechanism. Third, performance on futures contracts is guaranteed by a **clearinghouse**—a financial institution associated with the futures exchange that guarantees the financial integrity of the market to all traders. Fourth, all futures contracts require that traders post margin in order to trade. **Margin** is a good faith deposit made by the prospective futures trader to indicate his or her willingness and ability to fulfill all financial obligations that may arise from trading futures. Fifth, futures markets are regulated by an identifiable government agency, while forward contracts in general trade in an unregulated market.

While these important features of futures markets will be explored in more detail in Chapter 2, we must bear in mind that forwards and futures are essentially similar contracts. In fact, they differ only in the institutional setting in which they trade; the principles for pricing and the use of forwards and futures are almost identical.

Options

Everyone has options. When buying a car, we can add more equipment to the automobile that is "optional at extra cost." In this sense, an option is a choice. This book examines options in financial markets. These are a very specific type of option—an option created through a financial contract.

Options have played a role in security markets for many years, although no one can be certain how long. Initially, options were created by individualized contracts between two parties. However, until recently, there was no organized exchange for trading options. The development of option exchanges stimulated greater interest and more active trading of options. In many respects, the recent history of option trading can be regarded as an option revolution.

Every option is either a **call option** or a **put option.**[4] The owner of a call option has the right to purchase the underlying good at a specific price, and this right lasts until a specific date. The owner of a put option has the right to sell the underlying good at a specific price, and this right lasts until a specific date. In short, the owner of a call option can call the underlying good away from someone else.

Likewise, the owner of a put option can put the good to someone else by making the opposite party buy the good. To acquire these rights, owners of options buy them from other traders by paying the price, or premium, to a seller.

Options are created only by buying and selling. Therefore, for every owner of an option, there is a seller. The seller of an option is also known as an **option writer.** The seller receives payment for an option from the purchaser. In exchange for the payment received, the seller confers rights to the option owner. The seller of a call option receives payment and, in exchange, gives the owner of a call option the right to purchase the underlying good at a specific price, with this right lasting for a specific time. The seller of a put option receives payment from the purchaser and promises to buy the underlying good at a specific price for a specific time, if the owner of the put option chooses.

In these agreements, all rights lie with the owner of the option. In purchasing an option, the buyer makes payments and receives rights to buy or sell the underlying good on specific terms. In selling an option, the seller receives payment and promises to sell or purchase the underlying good on specific terms—at the discretion of the option owner. With put and call options and buyers and sellers, four basic positions are possible. Notice that the owner of an option has all the rights. After all, that is what the owner purchases. The seller of an option has all the obligations, because the seller undertakes obligations in exchange for payment.

Options on Futures

An **option on a futures** contract or a **futures option** is an option that takes a futures contract as its underlying good. It contrasts with an **option on the physical**—an option on the good itself rather than an option on a futures contract. For example, in the gold market, the physical gold trades. In addition, options on gold and futures contracts on gold trade as well. The option on gold itself is an option on the physical, while the option on the gold futures contract is a futures option. Similarly, in the equity market, options trade on a stock index (an option on a physical) and options trade on stock index futures (a futures option).

The structure of a futures option is very similar to that of an option on the physical. For both instruments, the option owner has the right to exercise, and the seller has a duty to perform upon exercise. Upon exercising a futures option, however, the call owner receives a long position in the underlying futures at the settlement price prevailing at the time of exercise. The call owner also receives a payment that equals the settlement price minus the exercise price of the futures option. (The call owner would not exercise if the futures settlement price did not exceed the exercise price.) When a call option is exercised against her, a call seller receives a short position in the underlying futures at the settlement price prevailing at the time of exercise. In addition, the short call trader pays the long trader the futures settlement price minus the exercise price.

When the owner of a futures put option exercises, he receives a short position in the underlying futures contract at the settlement price prevailing at the time of exercise. In addition, the put owner receives a payment that equals the exercise price minus the futures settlement price. (The put owner would not exercise unless the exercise price exceeded the futures settlement price.) Upon exercise, the put seller receives a long position in the underlying futures contract, and the put seller must pay the exercise price minus the settlement price.

Swaps

A **swap** is an agreement between two or more parties to exchange sequences 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 parties that agree to the swap are known as **counterparties.** The cash flows that the counterparties make are generally tied to the value of debt instruments or to the value of foreign currencies. Therefore, the two basic kinds of swaps are **interest rate swaps** and **currency swaps.**

As we will see in considerable detail, the principal futures and options markets are regulated markets, and they are dominated by the exchanges where trading takes place. The futures and options contracts are highly standardized, they are limited to relatively few goods, and they have a few fixed expirations per year. In addition, the horizon over which they trade is often much shorter than the risk horizon that businesses face.

In large part, the swap market has emerged because swaps escape many of the limitations inherent in futures and exchange-traded options markets. Swaps, of course, have some limitations of their own. Swaps are custom-tailored to the needs of the counterparties. If they wish, the potential counterparties can start with a blank sheet of paper and develop a contract that is completely dedicated to meeting their particular needs. Thus, swap agreements are more likely to meet the specific needs of the counterparties than exchange-traded instruments. The counterparties can select the dollar amount that they wish to swap, without regard to some fixed contract terms, such as those that prevail in exchange-traded instruments. Similarly, the swap counterparties choose the exact maturity that they need, rather than having to fit their needs to the offerings available on an exchange. This is very important in the swap market, because this flexibility allows the counterparties to deal with much longer horizons than can be addressed through exchange-traded instruments. Because the market does not operate on an exchange, participants have far greater privacy, and they also escape regulation to a considerable degree.

Applications of Financial Derivatives

Financial derivatives have attained their overwhelming popularity and rapid growth for a variety of reasons. This section briefly introduces some of the main benefits that financial derivatives bring to the market. Not all financial derivatives have the same virtues or the same limitations. Therefore, the benefits of derivatives explored in this section do not apply equally to all of the instruments that we will consider. However, subsequent chapters explore the specific applications of forwards, futures, options, and swaps in detail. Here we consider how financial derivatives help to make markets more nearly complete, how speculators and risk managers can use derivatives for their specific ends, and how many traders have been attracted to financial derivatives because of their trading efficiency, particularly their low transaction costs and highly liquid markets.

Market Completeness

In the theory of finance, a **complete market** is a market in which any and all identifiable payoffs can be obtained by trading the securities available in the market. For example, a complete market would allow a trader to purchase a security or set of securities that would pay off if and only if the Dow Jones Industrial Average rose by 99 to 100 points over the next month. It is quite difficult to trade any combination of stocks and bonds that would have a payoff in this circumstance and no other. If the financial instruments available in a market were not sufficiently rich and diverse to permit such a speculation, the market would be deemed incomplete.

From this definition of market completeness, we see that a complete market is an idealization that is most likely always unobtainable in practice. Nonetheless, completeness is a desirable characteristic of a financial market, because it can be shown that access to a complete market increases the welfare of the agents in the economy. Even if an actual market can never be truly complete, the more closely the market approaches completeness, the better off are the economic agents in the economy.