



# FUTURES, OPTIONS, & SWAPS

SECOND EDITION

ROBERT W. KOLB



 **BLACKWELL**  
*Business*

# **Futures, Options, and Swaps**

## **Second Edition**

**Robert W. Kolb**

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# **Futures, Options, and Swaps**

## **Second Edition**



# PREFACE

*Futures, Options, and Swaps, 2e*, 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. Also, an interest rate swap is analyzed as a portfolio of forward contracts or 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 Exchange 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 10–18 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*, is a new chapter in this edition. It details the payoffs for a wide variety of exotic options, presents the valuation formulas, and includes a detailed computational example.

## Swaps

The swaps market is the subject of Chapter 19, *The Swaps Market: Introduction*, and Chapter 20, *The Swaps Market: Refinements*. Chapter 19 introduces the institutional features of the market and

considers plain vanilla interest rate and foreign currency swaps. Chapter 20 extends the analysis “beyond plain vanilla,” and it also illustrates how to use swaps to manage more complicated risk situations.

## ***OPTION! SOFTWARE***

Each copy of the text is accompanied by an IBM PC-compatible diskette, including the program **OPTION!**, which can compute virtually every option 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 60 exercises designed to enhance the understanding of option pricing principles and applications. These exercises can all be solved using **OPTION!** software.

## ***FUTURES DATA***

The diskette that accompanies this text also includes a variety of data from the futures market. These data include daily prices on many different futures contracts, with an emphasis on financial futures. The *Futures Data Guide* at the end of this book explains how the data are organized. These data provide an opportunity for analyzing actual futures pricing relationships.

## ***CHANGES IN THE SECOND EDITION***

For the second edition of *Futures, Options, and Swaps*, all time-sensitive material has been updated as appropriate. The major change to this edition is the inclusion of a new Chapter 18 on “Exotic Options.” This chapter reflects the emergence of an important new class of options. It considers these options in detail, including detailed pricing formulas and worked-out computational examples of each type of option. In addition, the **OPTION!** Software that accompanies this book has been expanded to provide full coverage of all of the exotic options covered in the new Chapter 18.

New topics have been added to reflect changes in the markets. Specific examples are: Chapter 2, which now provides a discussion of the new FASB proposals for accounting for futures contracts and also analyzes the current state of electronic trading with an emphasis on the competing systems of the Chicago Mercantile Exchange (GLOBEX) and the Chicago Board of Trade (Project A); Chapter 5, which focuses greater attention on Eurodollar futures, reflecting their growth in importance for the markets; and Chapter 7, which features a discussion of the demise of Barings Bank in the context of index arbitrage. As with the first edition, the second edition is accompanied by futures data that have been expanded and updated.

## ***ACKNOWLEDGMENTS***

As a second edition, much of the material contained here is tried and proven. In writing this book, I have drawn heavily on all five editions of *Understanding Futures Markets* and three editions of *Options: An Introduction*. Thus, most of the material here has been class-tested in many universities.

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 George Wang of the Commodity Futures Trading Commission, Peter Alonzi of the Chicago Board of Trade, Tom Gosnell of Oklahoma State University, and Raffaella Cremonesi and Suk Hun Lee of Loyola University of Chicago.

Producing *Futures, Options, and Swaps, 2e*, required the dedicated efforts of a professional production staff. I would like to thank Rolf Janke, Editorial Director, Mary Beckwith, Assistant Editor, Jan Phillips, Production Manager, Megan Zuckerman, Graphic Designer, and Diane McCree, Production Editor, for their assistance and expertise in putting this project together. Of course, I alone am responsible for any remaining deficiencies.

Robert W. Kolb



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## CHAPTER

# 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 (i.e., is *derived* from) 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 these instruments, 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 playing 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 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. Two software items accompany this text. The first is a computer program called **OPTION!**, which allows the reader to compute option prices with ease. In addition, the accompanying diskette contains a variety of futures market data, which this chapter also briefly explains.

## 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, while 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 upon.<sup>1</sup> 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.<sup>2</sup>

## *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.<sup>3</sup> 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, and the principles for pricing and using 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**.<sup>4</sup> 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 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 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 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 make markets more nearly complete, how speculators and risk managers can use derivatives for their specific ends, and