Fundamentals of

FUTURES
AND
OPTIONS
MARKETS

Fourth Edition

JOHN C. HULL

FOURTH EDITION

FUNDAMENTALS OF FUTURES AND OPTIONS MARKETS

John C. Hull

Maple Financial Group Professor of Derivatives and Risk Management
Director, Bonham Center for Finance
Joseph L. Rotman School of Management
University of Toronto

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Preface

This book has been written for undergraduate and graduate elective courses offered by business, economics, and other faculties. Many practitioners who want to acquire a working knowledge of futures and options markets will also find the book useful.

I was persuaded to write this book by colleagues who liked my other book *Options, Futures, and Other Derivatives*, but found the material a little too advanced for their students. *Fundamentals of Futures and Options Markets* (formerly *Introduction to Futures and Options Markets*) covers some of the same ground as *Options, Futures, and Other Derivatives*—but in a way that readers who have had limited training in mathematics will find easier to understand. One important difference between this book and my other one is that there is no calculus in this book.

The text can be used in a number of different ways. Instructors who like to focus on one- and two-step binomial trees when valuing options may wish to cover only the first 10 chapters. Instructors who feel that swaps are adequately covered by other courses can choose to omit Chapter 6. There are many different ways in which Chapters 11 to 21 can be used. Instructors who feel that the material in Chapters 14, 16, 17, or 18 is too specialized can skip one or more of these chapters. Some instructors may choose to devote relatively more time to futures and swaps markets (Chapters 1 to 6); others may choose to structure their course mostly around options markets (Chapters 7 to 21). The three new Chapters (19 to 21) contain very little mathematics and do not rely heavily on earlier material. I find they work well when used in the last two to three weeks of a course regardless of what is covered earlier.

Chapter 1 provides an introduction to futures and options markets and outlines the different ways in which they can be used. Chapter 2 describes the mechanics of how futures and forward contracts work. Chapter 3 shows how forward and futures prices can be determined in a variety of different situations by using pure arbitrage arguments. Chapter 4 discusses how futures contracts can be used for hedging. Chapter 5 deals with interest rate markets. Chapter 6 covers swaps. Chapter 7 describes the mechanics of how options markets work. Chapter 8 develops some relationships that must hold in options markets if there are to be no arbitrage opportunities. Chapter 9 outlines a number of different trading strategies involving options. Chapter 10 shows how options can be priced using one- and two-step binomial trees. Chapter 11 discusses the pricing of stock options using the Black–Scholes model. Chapter 12 extends the ideas in Chapter 11 to cover options on stock indices and currencies. Chapter 13 extends the ideas in Chapter 11 to futures options. Chapter 14 discusses volatility smiles. Chapter 15 provides a detailed treatment of hedge parameters such as delta, gamma, and vega. It also discusses portfolio insurance. Chapter 16 explains how to calculate and use the value-at-risk measure. Chapter 17 covers the use of multistep binomial trees to value American options. Chapter 18 focuses on interest rate options. Chapter 19 covers exotic options, mortgage-backed securities, and nonstandard swaps. Chapter 20 covers some relatively new derivative products: credit derivatives, weather derivatives, energy derivatives, and

insurance derivatives. Chapter 21 describes some well-publicized derivatives disasters and reviews the lessons we can learn from them.

At the end of each chapter (except the last one) there are seven quiz questions that students can use to provide a quick test of their understanding of the key concepts. The answers to these are at the end of the book.

What's New?

The major changes in this edition include:

1. Three new chapters have been added (Chapters 19, 20, and 21). These are entitled *Exotic Options and Other Nonstandard Products*; *Credit, Weather, Energy, and Insurance Derivatives*; and *Derivative Mishaps and What We Can Learn from Them*. In my experience, students really enjoy covering the material in these chapters.

2. Chapter 5 on *Interest Rate Markets* has been rewritten to make it more relevant and easier to understand.

3. Chapter 14 on *Volatility Smiles* has been rewritten so that it accurately reflects current trading practices. This chapter now appears earlier in the book than the corresponding chapter in the third edition.

4. Chapter 16 on *Value at Risk* has been rewritten to reflect developments in this area.

5. The notation has been improved. For example, S_0 and F_0 are now used to refer to the spot price and the forward/futures price today.

6. Many new problems have been added.

Material has been updated throughout the book and the presentation improved.

Software

New Excel-based software, DerivaGem, is included with the book. This software is a great improvement over that included with previous editions. It has been carefully designed to complement the material in the text. Users can calculate options prices, imply volatilities, and calculate Greek letters for European options, American options, exotic options, and interest rate options. The software can be used to display binomial trees (see, for example, Figures 17.3 to 17.9) and to produce many different charts showing the impact of different variables on either option prices or the Greek letters.

The software is described more fully at the end of the book. Updates to the software can be downloaded from my Web site

$$\text{http://www.rotman.utoronto.ca/}\tilde{}\text{hull}$$

Slides

Several hundred PowerPoint slides can be downloaded from my Web site. They use only standard fonts. Instructors adopting the book are welcome to adapt the slides to meet their own needs.

Answers to Questions

Solutions to all end-of-chapter problems (except quiz questions) were available only in the Instructors Manual for the first three editions of this book. Over the years, many people have asked me to make the solutions more generally available. I have hesitated

to do this because it would prevent instructors from using the problems as assignment questions.

In this edition I have dealt with this issue by dividing the end-of-chapter problems into two groups: "Questions and Problems" and "Assignment Questions." There are over 200 Questions and Problems, and answers to these are in the Solutions Manual for *Fundamentals of Futures and Options Markets*, which is published by Prentice Hall. There are about 70 Assignment Questions. Solutions to these are available only in the Instructors Manual.

Acknowledgments

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I would particularly like to thank Alan White. Alan is a colleague at the University of Toronto with whom I have been carrying out joint research in options and futures for the last 18 years. We have spent many hours discussing different issues concerning options and futures markets. Many of the new ideas in this book, and many of the new ways used to explain old ideas, are as much Alan's as mine.

Special thanks are due to many people at Prentice Hall for their enthusiasm, advice, and encouragement. I would particularly like to thank Mickey Cox (my editor), P. J. Boardman (the editor-in-chief), and Richard DeLorenzo (the production editor). I am also grateful to Scott Barr, Leah Jewell, Paul Donnelly, and Maureen Riopelle, who at different times have played key roles in the development of this book.

I welcome comments on the book from readers. My e-mail address is

<div align="center">hull@rotman.utoronto.ca</div>

<div align="right">John Hull
University of Toronto</div>

Contents

Introduction

In recent years futures and options markets have become increasingly important in the world of finance and investments. We have now reached the stage where it is essential for all finance professionals to understand how these markets work, how they can be used, and what determines prices in them. This book addresses these issues.

In this opening chapter we take a first look at futures, forward, and options markets. We examine their history and provide an overview of how they are used by hedgers, by speculators, and by arbitrageurs. Later chapters will give more details and elaborate on many of the topics introduced here.

1.1 FUTURES CONTRACTS

A *futures contract* is an agreement to buy or sell an asset at a certain time in the future for a certain price. There are many exchanges throughout the world trading futures contracts. The two largest futures exchanges in the United States are the Chicago Board of Trade (www.cbot.com) and the Chicago Mercantile Exchange (www.cme.com). The two largest exchanges in Europe are the London International Financial Futures and Options Exchange (www.liffe.com) and Eurex (www.eurexchange.com). Other large exchanges include Bolsa de Mercadorias y Futuros (www.bmf.com.br) in São Paulo, the Tokyo International Financial Futures Exchange (www.tiffe.or.jp), the Singapore International Monetary Exchange (www.simex.com.sg), and the Sydney Futures Exchange (www.sfe.com.au). For a more complete list, see the table at the end of this book.

We will examine how a futures contract comes into existence by considering the corn futures that trade on the Chicago Board of Trade. In March an investor in New York might call a broker with instructions to buy 5,000 bushels of corn for July delivery. The broker would immediately pass these instructions on to a trader at the Chicago Board of Trade. At about the same time, another investor in Kansas might instruct a broker to sell 5,000 bushels of corn for July delivery. These instructions would also be passed on to a trader at the Chicago Board of Trade. The two traders would meet, they would agree on a price to be paid for the corn in July, and the deal would be done.[1]

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[1] As we discuss later, exchanges where traders physically meet are increasingly being replaced by electronic exchanges.

The investor in New York who agreed to buy has what is termed a *long futures position*; the investor in Kansas who agreed to sell has what is termed a *short futures position*. The price agreed to by the two traders is known as the *futures price*. We will suppose the price is 170 cents per bushel. This price, like any other price, is determined by the laws of supply and demand. If at a particular time more traders wish to sell July corn than to buy July corn, the price will go down. New buyers will then enter the market so that a balance between buyers and sellers is maintained. If more traders wish to buy July corn than to sell July corn, the price goes up—for similar reasons.

Issues such as margin requirements, daily settlement procedures, trading practices, commissions, bid–offer spreads, and the role of the exchange clearinghouse will be discussed in Chapter 2. For the time being, we can assume that the end result of the events just described is that the investor in New York has agreed to buy 5,000 bushels of corn for 170 cents per bushel in July and the investor in Kansas has agreed to sell 5,000 bushels of corn for 170 cents per bushel in July. Both sides have entered into a binding contract.

1.2 HISTORY OF FUTURES MARKETS

Futures markets can be traced back to the Middle Ages. They were originally developed to meet the needs of farmers and merchants. Consider the position of a farmer in April of a certain year who will harvest a known amount of grain in June. There is uncertainty about the price the farmer will receive. In years of scarcity it might be possible to obtain relatively high prices—particularly if the farmer is not in a hurry to sell. On the other hand, in years of oversupply the grain might have to be disposed of at fire-sale prices. The farmer and the farmer's family are clearly exposed to a great deal of risk.

Consider next a company that has an ongoing requirement for grain. The company is also exposed to price risk. In some years an oversupply situation may create favorable prices; in other years scarcity may cause the prices to be exorbitant. It clearly makes sense for the farmer and the company to get together in April (or even earlier) and agree on a price for the farmer's production of grain in June. In other words, it makes sense for them to negotiate a type of futures contract. The contract provides a way for each side to eliminate the risk it faces because of the uncertain future price of grain.

We might ask what happens to the company's requirements for grain during the rest of the year. Once the harvest season is over, the grain must be stored until the next season. In undertaking this storage, the company does not bear any price risk, but does incur the costs of storage. If the farmer or some other person stores the grain, the company and the storer both face risks associated with the future grain price, and again there is a clear role for futures contracts.

The Chicago Board of Trade

The Chicago Board of Trade was established in 1848 to bring farmers and merchants together. Initially its main task was to standardize the quantities and qualities of the grains that were traded. Within a few years the first futures-type contract was developed. It was known as a *to-arrive contract*. Speculators soon became interested in the contract and found trading the contract to be an attractive alternative to trading the grain itself. The Chicago Board of Trade now offers futures contracts on many different underlying

assets, including corn, oats, soybeans, soybean meal, soybean oil, wheat, Treasury bonds, and Treasury notes.

The Chicago Mercantile Exchange

In 1874 the Chicago Produce Exchange was established, providing a market for butter, eggs, poultry, and other perishable agricultural products. In 1898 the butter and egg dealers withdrew from the exchange to form the Chicago Butter and Egg Board. In 1919 this was renamed the Chicago Mercantile Exchange (CME) and was reorganized for futures trading. Since then, the exchange has provided a futures market for many commodities, including pork bellies (1961), live cattle (1964), live hogs (1966), and feeder cattle (1971). In 1982 it introduced a futures contract on the Standard & Poor's (S&P) 500 Stock Index.

The Chicago Mercantile Exchange started futures trading in foreign currencies in 1972. The currency futures traded now include the British pound, the Canadian dollar, the Japanese yen, the Swiss franc, the German mark, the Australian dollar, the Mexican peso, the Brazilian real, the South African rand, the New Zealand dollar, the Russian rouble, and the euro. The Chicago Mercantile Exchange also trades a very popular Eurodollar futures contract.

Electronic Trading

Traditionally futures contracts have been traded by what is known as the *open-outcry system*. This involves traders physically meeting on the floor of the exchange and using a complicated set of hand signals to indicate the trades they would like to carry out. This system is still used by the Chicago Board of Trade and the Chicago Mercantile Exchange during regular trading hours. In recent years, other exchanges have replaced the open-outcry system with *electronic trading*. This involves traders entering their required trades at a keyboard and a computer being used to match buyers and sellers. Both the open-outcry system and electronic trading have their advocates, but there seems little doubt that eventually all exchanges will use electronic trading.

1.3 THE OVER-THE-COUNTER MARKET

Not all trading is done on exchanges. What is known as the *over-the-counter market* is an important alternative to exchanges. It is a telephone- and computer-linked network of dealers, who do not physically meet. Trades are done over the phone and are usually between two financial institutions or between a financial institution and one of its corporate clients. Financial institutions often act as market makers for the more commonly traded instruments. This means that they are always prepared to quote both a bid price (a price at which they are prepared to buy) and an offer price (a price at which they are prepared to sell).

Telephone conversations in the over-the-counter market are usually taped. If there is a dispute about what was agreed, the tapes are replayed to resolve the issue. Trades in the over-the-counter market are typically much larger than trades in the exchange-traded market. A key advantage of the over-the-counter market is that the terms of a contract do not have to be those specified by an exchange. Market participants are free to negotiate any mutually attractive deal. A disadvantage is that there is usually some credit risk in an over-the-counter trade (that is, there is a small risk that the contract