Fundamentals *of* Futures *and* Options Markets

Ninth Edition

John C. Hull

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FUNDAMENTALS OF FUTURES AND OPTIONS MARKETS

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To My Students

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Preface

I was originally persuaded to write this book by colleagues who liked my book *Options, Futures, and Other Derivatives*, but found the material a little too advanced for their students. *Fundamentals of 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 find easier to understand. One important difference between the two books is that there is no calculus in this book. *Fundamentals* is suitable for undergraduate and graduate elective courses offered by business, economics, and other faculties. In addition, many practitioners who want to improve their understanding of futures and options markets will find the book useful.

Instructors can use this book in a many different ways. Some may choose to cover only the first 12 chapters, finishing with binomial trees. For those who want to do more, there are many different sequences in which Chapters 13 to 25 can be covered. From Chapter 18 onward, each chapter has been designed so that it is independent of the others and can be included in or omitted from a course without causing problems. I recommend finishing a course with Chapter 25, which students always find interesting and entertaining.

What's New in This Edition?

Many changes have been made to update material and improve the presentation. The derivatives markets' move toward OIS discounting has continued since the eighth edition was written. This has allowed me to streamline the material in the first seven chapters of *Fundamentals*. LIBOR discounting is no longer presented as a way to value instruments such as swaps and forward rate agreements. The valuation of these instruments requires (a) forward rates for the rate used to calculate payments (usually LIBOR) and (b) the zero-coupon risk-free zero curve used for discounting (usually the OIS zero curve). Most instructors will find the new presentation appealing and more logical. It can be extended to situations where payments are dependent on any risky rate. Other changes include:

1. More on the new regulations concerning the trading and clearing of OTC derivatives.
2. A major revision of the swaps chapter (Chapter 7) to improve the presentation of material and reflect the derivative markets' move to OIS discounting.
3. A fuller description of the impact of daily settlement when futures contracts are used for hedging.
4. More details on the calculation and use of Greek letters.
5. More discussion of the expected shortfall measure, reflecting its increasing importance.

6. A new version of the software DerivaGem, tailored to the needs of readers of this book.

Other Points of Distinction

Software

DerivaGem Fundamentals 4.00 (DG400f) is included with this book. This consists of two Excel applications: the *Options Calculator* and the *Applications Builder*. The Options Calculator consists of easy-to-use software for valuing many of the derivatives discussed in this book. The Applications Builder consists of a number of Excel functions from which users can build their own applications. It includes some sample applications and enables students to explore the properties of options and numerical procedures. It also allows more interesting assignments to be designed.

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

www-2.rotman.utoronto.ca/~hull

End-of-Chapter Problems

At the end of each chapter (except the last) there are seven quiz questions, which students can use to provide a quick test of their understanding of the key concepts. The answers to these are given at the end of the book. In addition, there are a multitude of practice questions and further questions in the book.

Solutions Manual and Study Guide

Answers to the practice questions and advice to readers on how each chapter should be studied are in the *Solutions Manual and Study Guide* (ISBN 0-13-408365-2), which is published by Pearson and can be purchased separately from this book.

For the Instructor

At the Instructor Resource Center, www.pearsonhighered.com/irc, instructors can easily register to gain access to a variety of instructor resources available with this text in downloadable format.

If assistance is needed, Pearson's dedicated technical support team is ready to help with the media supplements that accompany this text. Visit http://247.pearsoned.com for answers to frequently asked questions and toll-free user support phone numbers.

The following supplements are available with this text:

- PowerPoint Presentations (adopting instructors can adapt the slides to meet their needs)
- *Instructors Manual* (including answers to both practice questions and further questions)
- Test Bank (20 multiple choice questions per chapter)

Acknowledgments

Many people have played a part in the development of successive editions of this book. Indeed, the list of people who have provided me with feedback on the book is now so long that it is not possible to mention everyone. I have benefited from the advice of many academics who have taught from the book and from the comments of many derivatives practitioners. I would like to thank the students on my courses at the University of Toronto, who have made many suggestions on how the material can be improved. Eddie Mizzi of the Geometric Press did a fine job handling the page composition.

Alan White, a colleague at the University of Toronto, deserves a special acknowledgment. Alan and I have been carrying out joint research and consulting in the areas of derivatives and risk management for about 30 years. During that time, we have spent many hours discussing key issues. 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. Alan has done most of the development work on the DerivaGem software.

Special thanks are due to many people at Pearson for their enthusiasm, advice, and encouragement. I would particularly like to mention Donna Battista, Neeraj Bhalla, and Alison Kalil. I welcome comments on the book from readers. My email address is:

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About the Author

John Hull is the Maple Financial Professor of Derivatives and Risk Management at the Joseph L. Rotman School of Management, University of Toronto. He is an internationally recognized authority on derivatives and risk management with many publications in this area. His work has an applied focus. In 1999 he was voted Financial Engineer of the Year by the International Association of Financial Engineers. He has acted as consultant to many North American, Japanese, and European financial institutions. He has won many teaching awards, including University of Toronto's prestigious Northrop Frye award.

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Introduction

Derivatives markets have become increasingly important in the world of finance and investments. It is now 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.

Derivatives are traded on exchanges and in what are termed "over-the-counter" (OTC) markets. The two main products trading on exchanges are futures and options. In the over-the counter markets forwards, swaps, options, and a wide range of other derivatives transactions are agreed to. Prior to the crisis which started in 2007, the OTC derivatives market was relatively free from regulation. This has now changed. As we will explain, OTC market participants are now subject to rules requiring that trades be reported, that collateral be provided, and that trading platforms be used.

This opening chapter starts by providing an introduction to futures markets and futures exchanges. It then compares exchange-traded derivatives markets with OTC derivatives markets and discusses forward contracts, which are the OTC counterpart of futures contracts. After that, it introduces options and outlines the activities of hedgers, speculators, and arbitrageurs in derivatives markets.

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. These include the CME Group (www.cmegroup.com), the Intercontinental Exchange (ICE; www.intercontinentalexchange.com), Euronext (www.euronext. com), Eurex (www.eurexchange.com), BM&FBOVESPA (www.bmfbovespa.com.br), the National Stock Exchange of India (www.nse-india.com), the Tokyo Financial Exchange (www.tfx.co.jp), and the China Financial Futures Exchange (www.cffex. com.cn). A table at the end of this book gives a more complete list.

Futures exchanges allow people who want to buy or sell assets in the future to trade with each other. In June, a trader in New York might contact a broker with instructions to buy 5,000 bushels of corn for September delivery. The broker would immediately communicate the client's instructions to the CME Group. At about the same time,

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┌─────────────────────────────────────────────────────┐
│ June:  Trader takes a long position in a September     │
│        futures contract on corn at 400 cents per bushel│
└─────────────────────────────────────────────────────┘
                          │
                          ▼
┌─────────────────────────────────────────────────────┐
│ September:  Trader must buy 5,000 bushels of corn      │
│            for $20,000                                 │
└─────────────────────────────────────────────────────┘
```
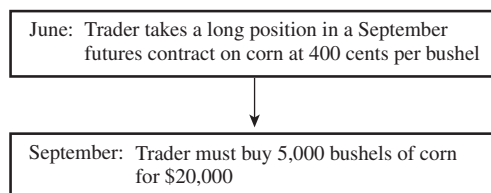
Figure 1.1 A futures contract (assuming it is held to maturity)

another trader in Kansas might instruct a broker to sell 5,000 bushels of corn for September delivery. These instructions would also be passed on to the CME Group. A price would be determined and the deal would be done.

The trader in New York who agreed to buy has what is termed a *long futures position*; the trader in Kansas who agreed to sell has what is termed a *short futures position*. The price is known as the *futures price*. We will suppose the price is 400 cents per bushel. This price, like any other price, is determined by the laws of supply and demand. If at a particular time more people wish to sell September corn than to buy September corn, the price goes down. New buyers will then enter the market so that a balance between buyers and sellers is maintained. If more people wish to buy September corn than to sell September 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 clearing house 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 trader in New York has agreed to buy 5,000 bushels of corn for 400 cents per bushel in September and the trader in Kansas has agreed to sell 5,000 bushels of corn for 400 cents per bushel in September. Both sides have entered into a binding contract. The contract is illustrated in Figure 1.1.

A futures price can be contrasted with the *spot price*. The spot price is for immediate, or almost immediate, delivery. The futures price is the price for delivery at some time in the future. The two are not usually equal. As we will see in later chapters, the futures price may be greater than or less than the spot price.

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 June of a certain year who will harvest a known amount of corn in September. There is uncertainty about the price the farmer will receive for the corn. 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 corn 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 corn. 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 can make sense for the farmer and the company to get together in June (or even earlier) and agree on a

price for the farmer's estimated production of corn in September. This involves them negotiating 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 corn.

We might ask what happens to the company's requirements for corn during the rest of the year. Once the harvest season is over, the corn must be stored until the next season. If the farmer stores the corn, the company and the farmer both face risks associated with the future corn price, and again there is a clear role for futures contracts.

The Chicago Board of Trade

The Chicago Board of Trade (CBOT) 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 CBOT developed futures contracts on many different underlying assets, including corn, oats, soybeans, soybean meal, soybean oil, wheat, Treasury bonds, and Treasury notes. It became part of the CME Group in 2007.

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 euro, British pound, Canadian dollar, Japanese yen, Swiss franc, Australian dollar, Mexican peso, Brazilian real, South African rand, New Zealand dollar, Russian rouble, Chinese renminbi, Swedish krona, Czech koruna, Hungarian forint, Israeli shekel, Korean won, Polish złoty, and Turkish lira. The Chicago Mercantile Exchange developed the very popular Eurodollar futures contract. (As later chapters will explain, this is a contract on the future value of a short-term interest rate.) It has also introduced futures contracts on weather and real estate.

The CME Group now includes the Chicago Board of Trade, the New York Mercantile Exchange, and the Kansas City Board of Trade.

Electronic Trading

Traditionally futures have been traded using what is known as the *open-outcry system*. This involves traders physically meeting on the floor of the exchange, known as the "trading pit," and using a complicated set of hand signals to indicate the trades they would like to carry out. In the example we considered earlier, one floor trader would represent the person in New York who wanted to buy September corn and another floor trader would represent the person in Kansas who wanted to sell September corn.

Business Snapshot 1.1 The Lehman Bankruptcy

On September 15, 2008, Lehman Brothers filed for bankruptcy. This was the largest bankruptcy in US history and its ramifications were felt throughout derivatives markets. Almost until the end, it seemed as though there was a good chance that Lehman would survive. A number of companies (e.g., the Korean Development Bank, Barclays Bank in the UK, and Bank of America) expressed interest in buying it, but none of these was able to close a deal. Many people thought that Lehman was ''too big to fail'' and that the US government would have to bail it out if no purchaser could be found. This proved not to be the case.

How did this happen? It was a combination of high leverage, risky investments, and liquidity problems. Commercial banks that take deposits are subject to regulations on the amount of capital they must keep. Lehman was an investment bank and not subject to these regulations. By 2007, its leverage ratio had increased to 31:1, which means that a 3–4% decline in the value of its assets would wipe out its capital. Dick Fuld, Lehman's Chairman and Chief Executive, encouraged an aggressive deal-making, risk-taking culture. He is reported to have told his executives: ''Every day is a battle. You have to kill the enemy.'' The Chief Risk Officer at Lehman was competent, but did not have much influence and was even removed from the executive committee in 2007. The risks taken by Lehman included large positions in the instruments created from subprime mortgages, which will be described in Chapter 8. Lehman funded much of its operations with short-term debt. When there was a loss of confidence in the company, lenders refused to roll over this funding, forcing it into bankruptcy.

Lehman was very active in the over-the-counter derivatives markets. It had over a million transactions outstanding with about 8,000 different counterparties. Lehman's counterparties were often required to post collateral and this collateral had in many cases been used by Lehman for various purposes. Litigation attempting to determine who owes what to whom has continued for many years after the bankruptcy filing.

Futures exchanges throughout the world have largely replaced the open outcry system by *electronic trading*, where traders enter their required trades at a keyboard and a computer is used to match buyers and sellers. Electronic trading has led to a growth in high-frequency and algorithmic trading, which involve the use of computer programs to initiate trades, often without human intervention.

1.3 THE OVER-THE-COUNTER MARKET

Futures contracts are very popular exchange-traded contracts. Options, which are introduced later in this chapter, also trade very actively on exchanges. But not all trading of derivatives is on exchanges. Many trades take place in the *over-the-counter* (OTC) market. Banks, other large financial institutions, fund managers, and corporations are the main participants in OTC derivatives markets. The number of derivatives transactions per year in OTC markets is smaller than in exchange-traded markets, but the average size of the transactions is much greater.