Fundamentals *of* Futures *and* Options Markets

Ninth Edition

John C. Hull

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FUNDAMENTALS OF FUTURES AND OPTIONS MARKETS

John C. Hull

Maple Financial Group Professor of Derivatives and Risk Management
Joseph L. Rotman School of Management
University of Toronto

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To My Students

CONTENTS IN BRIEF

BUSINESS SNAPSHOTS

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Contents

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:

hull@rotman.utoronto.ca

John Hull

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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CHAPTER 1

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,

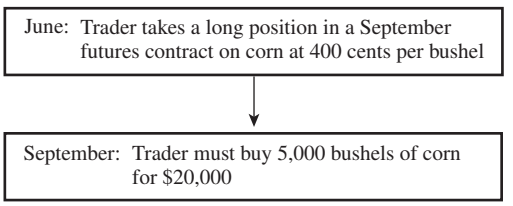

Figure 1.1 A futures contract (assuming it is held to maturity)

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.

Business Snapshot 1.2 Systemic risk

Systemic risk is the risk that a default by one financial institution will create a ''ripple effect'' that leads to defaults by other financial institutions and threatens the stability of the financial system. There are huge numbers of over-the-counter transactions between banks. If Bank A fails, Bank B may take a huge loss on the transactions it has with Bank A. This in turn could lead to Bank B failing. Bank C that has many outstanding transactions with both Bank A and Bank B might then take a large loss and experience severe financial difficulties; and so on.

The financial system has survived defaults such as Drexel in 1990 and Lehman Brothers in 2008, but regulators continue to be concerned. During the market turmoil of 2007 and 2008, many large financial institutions were bailed out, rather than being allowed to fail, because governments were concerned about systemic risk.

When a nonfinancial company wants to trade a derivative in the OTC market, it usually contacts a derivatives dealer (typically a large bank). If an agreement is reached, the derivatives dealer may absorb the risks as part of its portfolio. Alternatively, it may choose to enter into an offsetting transaction with another derivatives dealer.

Prior to the credit crisis, which started in 2007 and is discussed in some detail in Chapter 8, OTC derivatives markets were largely unregulated. Following the credit crisis and the failure of Lehman Brothers (see Business Snapshot 1.1), we have seen the development of many new regulations affecting the operation of OTC markets. The main purpose of the regulations is to improve the transparency of OTC markets and reduce systemic risk (see Business Snapshot 1.2 for a discussion of systemic risk). The over-the-counter market in some respects is being forced to become more like the exchange-traded market. Three important changes are:

1. Standardized OTC derivatives between two financial institutions in the United States must whenever possible be traded on what are referred to as *swap execution facilities* (SEFs). These are platforms similar to exchanges where market participants can contact each other to agree on trades.
2. There is a requirement in most parts of the world that a central counterparty (CCP) be used for most standardized derivatives transactions between two financial institutions. The CCP's role is to stand between the two sides in an over-the-counter derivatives transaction in much the same way that an exchange does in the exchange-traded derivatives market. CCPs are discussed in more detail in Chapter 2.
3. All trades must be reported to a central repository.

Market Size

Both the over-the-counter and the exchange-traded market for derivatives are huge. Although the statistics that are collected for the two markets are not exactly comparable, it is clear that the over-the-counter market is much larger than the exchange-traded market. The Bank for International Settlements (www.bis.org) started collecting statistics on the markets in 1998. Figure 1.2 compares (a) the estimated total principal amounts underlying transactions that were outstanding in the over-the-counter markets

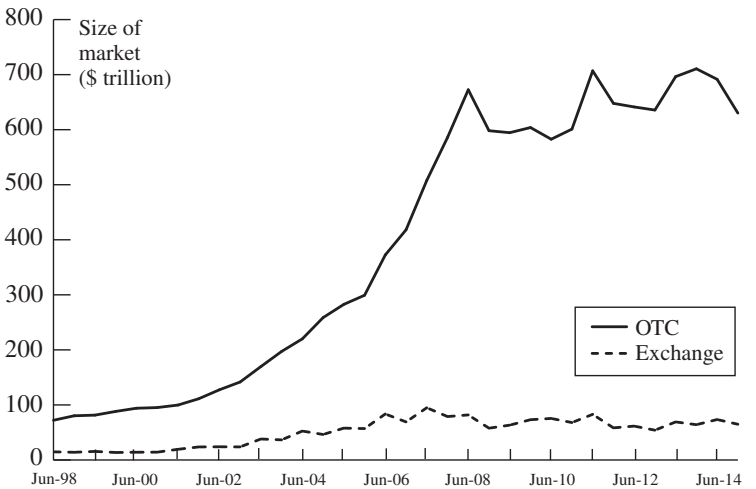

Figure 1.2 Size of over-the-counter and exchange-traded derivatives markets

between 1998 and 2014 and (b) the estimated total value of the assets underlying exchange-traded contracts during the same period. Using these measures, the size of the over-the-counter market was $630 trillion in December 2014 and that of the exchange-traded market was $65 trillion at this time. Figure 1.2 shows that the OTC market grew rapidly before the 2008 credit crisis and that there has been very little net growth since then.

In interpreting Figure 1.2, we should bear in mind that the principal underlying an over-the-counter transaction is not the same as its value. An example of an over-the-counter transaction is an agreement to buy 100 million U.S. dollars with British pounds at a predetermined exchange rate in one year. The total principal amount underlying this transaction is $100 million. However, the value of the transaction at a particular point in time might be only $1 million. The Bank for International Settlements estimates the gross market value of all OTC contracts outstanding in December 2014 to be about $21 trillion.[1]

1.4 FORWARD CONTRACTS

A forward contract is similar to a futures contracts in that it is an agreement to buy or sell an asset at a certain time in the future for a certain price. But, whereas futures contracts are traded on exchanges, forward contracts trade in the over-the-counter market.

Forward contracts on foreign exchange are very popular. Most large banks employ both spot and forward foreign exchange traders. Spot traders are trading a foreign currency for almost immediate delivery. Forward traders are trading for delivery at a future time. Table 1.1 provides quotes for the exchange rate between the British pound (GBP) and the U.S. dollar (USD) that might be made by a large international bank on

[1] A contract that is worth $1 million to one side and −$1 million to the other side would be counted as having a gross market value of $1 million.

Table 1.1 Spot and forward quotes for the USD/GBP exchange rate, May 13, 2015 (GBP = British pound; USD = U.S. dollar; quote is number of USD per GBP)

	Bid	*Offer*
Spot	1.5746	1.5750
1-month forward	1.5742	1.5747
3-month forward	1.5736	1.5742
6-month forward	1.5730	1.5736

May 13, 2015. The quote is for the number of USD per GBP. The first row indicates that the bank is prepared to buy GBP (also known as sterling) in the spot market (i.e., for virtually immediate delivery) at the rate of $1.5746 per GBP and sell sterling in the spot market at $1.5750 per GBP. The second row indicates that the bank is prepared to buy sterling in one month at $1.5742 per GBP and sell sterling in one month at $1.5747 per GBP; the third row indicates that it is prepared to buy sterling in three months at $1.5736 per GBP and sell sterling in three months at $1.5742 per GBP; and so on.

The quotes are for very large transactions. (As anyone who has traveled abroad knows, retail customers face much larger spreads between bid and offer quotes than those in Table 1.1.) After examining the quotes in Table 1.1, a large corporation might agree to sell £100 million in six months for $157.30 million to the bank as part of its hedging program.

There is a relationship between the forward price of a foreign currency, the spot price of the foreign currency, domestic interest rates, and foreign interest rates. This is explained in Chapter 5.

1.5 OPTIONS

Options are traded both on exchanges and in the over-the-counter markets. There are two types of option: calls and puts. A *call option* gives the holder the right to buy an asset by a certain date for a certain price. A *put option* gives the holder the right to sell an asset by a certain date for a certain price. The price in the contract is known as the *exercise price* or the *strike price*; the date in the contract is known as the *expiration date* or the *maturity date*. A *European option* can be exercised only on the maturity date; an *American option* can be exercised at any time during its life.

It should be emphasized that an option gives the holder the right to do something. The holder does not have to exercise this right. This fact distinguishes options from futures (or forward) contracts. The holder of a long futures contract is committed to buying an asset at a certain price at a certain time in the future. By contrast, the holder of a call option has a choice as to whether to buy the asset at a certain price at a certain time in the future. It costs nothing (except for margin requirements, which will be discussed in Chapter 2) to enter into a futures contract. By contrast, a trader must pay an up-front price, known as the *option premium*, for an option contract.

Table 1.2 Prices of call options on Google, May 13, 2015; stock price: bid \$532.20; offer \$532.34

Strike price (*\$*)	*June 2015*		*Sept. 2015*		*Dec. 2015*	
	Bid	*Offer*	*Bid*	*Offer*	*Bid*	*Offer*
475	57.90	61.80	66.00	68.90	73.50	76.50
500	34.80	37.10	45.90	47.90	54.90	56.60
525	16.70	17.30	30.40	31.30	40.20	41.10
550	5.60	6.20	18.60	19.40	28.10	29.00
575	1.55	1.80	10.50	11.30	18.80	20.20

The largest exchange in the world for trading stock options is the Chicago Board Options Exchange (CBOE). Table 1.2 gives the bid and offer quotes for some of the call options trading on Google (ticker symbol: GOOG) on May 13, 2015. Table 1.3 does the same for put options trading on Google on that date. The tables have been constructed from data on the CBOE web site. The Google stock price at the time of the quotes was bid 532.20, offer 532.34. The bid–offer spread for an option, as a percentage of its price, is greater than that for the underlying stock and depends on the volume of trading. The option strike prices in the tables are \$475, \$500, \$525, \$550, and \$575. The maturities are June 2015, September 2015, and December 2015. The June options have a maturity date of June 19, 2015; the September options have a maturity date of September 18, 2015; the December options have a maturity date of December 18, 2012. (The maturity date is the third Friday of the delivery month.)

The tables illustrate a number of properties of options. The price of a call option decreases as the strike price increases; the price of a put option increases as the strike price increases. Both types of options tend to become more valuable as their time to maturity increases. These properties of options will be discussed further in Chapter 10.

Suppose that a trader instructs a broker to buy one December call option contract on Google with a strike price of \$550. The broker will relay these instructions to a trader at the CBOE and the deal will be done. The (offer) price is \$29.00, as indicated in Table 1.2. This is the price for an option to buy one share. In the United States, an

Table 1.3 Prices of put options on Google, May 13, 2015; stock price: \$532.20; offer \$532.34

Strike price (*\$*)	*June 2015*		*Sept. 2015*		*Dec. 2015*	
	Bid	*Offer*	*Bid*	*Offer*	*Bid*	*Offer*
475	0.95	1.05	5.50	9.20	12.50	15.20
500	2.95	3.30	13.00	13.80	21.30	22.10
525	9.40	9.90	22.40	23.20	31.30	32.00
550	22.90	24.40	35.20	36.40	44.10	45.00
575	42.70	45.80	51.90	53.50	59.70	61.00

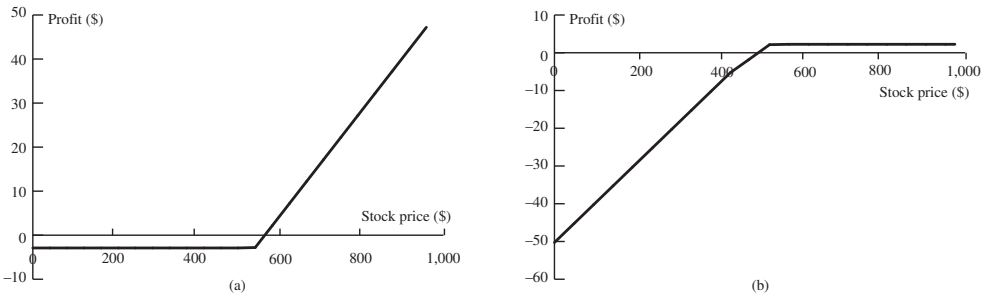

Figure 1.3 Net profit from (a) purchasing a contract consisting of 100 Google December call options with a strike price of $550 and (b) selling a contract consisting of 100 Google September put options with a strike price of $525

option contract is an agreement to buy or sell 100 shares. Therefore, the trader must arrange for $2,900 to be remitted to the exchange through the broker. The exchange will then arrange for this amount to be passed on to the party on the other side of the transaction.

In our example, the trader has obtained at a cost of $2,900 the right to buy 100 Google shares for $550 each. If the price of Google does not not rise above $550.00 by December 18, 2015, the option is not exercised and the trader loses $2,900.[2] But if Google does well and the option is exercised when the bid price for the stock is $650, the trader is able to buy 100 shares at $550 and immediately sell them for $650 for a profit of $10,000—or $7,100 when the initial cost of the options is taken into account.[3]

An alternative trade would be to sell one September put option contract with a strike price of $525 at the bid price of $22.40. This would lead to an immediate cash inflow of $100 \times 22.40 = \$2,240$. If the Google stock price stays above $525, this option is not exercised and the trader makes a profit of this amount. However, if stock price falls and the option is exercised when the stock price is, say, $480 there is a loss. The trader must buy 100 shares at $525 when they are worth only $480. This leads to a loss of $4,500, or $2,260 when the initial amount received for the option contract is taken into account.

The stock options trading on the CBOE are American (i.e., they can be exercised at any time). If we assume for simplicity that they are European, so that they can be exercised only at maturity, the trader's profit as a function of the final stock price for the two trades we have considered is shown in Figure 1.3.

Further details about the operation of options markets and how prices such as those in Tables 1.2 and 1.3 are determined by traders are given in later chapters. At this stage we note that there are four types of participants in options markets:

1. Buyers of calls
2. Sellers of calls

[2] The calculations here ignore commissions paid by the trader.

[3] The calculations here ignore the effect of discounting. Theoretically, the $10,000 should be discounted from the time of exercise to the purchase date when calculating the payoff.

3. Buyers of puts
4. Sellers of puts

Buyers are referred to as having *long positions*; sellers are referred to as having *short positions*. Selling an option is also known as *writing the option*.

1.6 HISTORY OF OPTIONS MARKETS

The first trading in put and call options began in Europe and in the United States as early as the eighteenth century. In the early years the market got a bad name because of certain corrupt practices. One of these involved brokers being given options on a certain stock as an inducement for them to recommend the stock to their clients.

Put and Call Brokers and Dealers Association

In the early 1900s a group of firms set up the Put and Call Brokers and Dealers Association. The aim of this association was to provide a mechanism for bringing buyers and sellers together. Traders who wanted to buy an option would contact one of the member firms. This firm would attempt to find a seller or writer of the option from either its own clients or those of other member firms. If no seller could be found, the firm would undertake to write the option itself in return for what was deemed to be an appropriate price.

The options market of the Put and Call Brokers and Dealers Association suffered from two deficiencies. First, there was no secondary market. The buyer of an option did not have the right to sell it to another party prior to expiration. Second, there was no mechanism to guarantee that the writer of the option would honor the contract. If the writer did not live up to the agreement when the option was exercised, the buyer had to resort to costly lawsuits.

The Formation of Options Exchanges

In April 1973 the Chicago Board of Trade set up a new exchange, the Chicago Board Options Exchange, specifically for the purpose of trading stock options. Since then options markets have become increasingly popular. By the early 1980s the volume of trading had grown so rapidly that the number of shares underlying the stock option contracts traded each day in United States exceeded the daily volume of shares traded on the New York Stock Exchange.

The exchanges trading options in the United States now include the Chicago Board Options Exchange (www.cboe.com), NASDAQ OMX (www.nasdaqtrader.com), NYSE Euronext (www.euronext.com), the International Securities Exchange (www.iseoptions.com), and the Boston Options Exchange (www.bostonoptions.com). Options trade on several thousand different stocks as well as stock indices, foreign currencies, and other assets.

Most exchanges offering futures contracts also offer options on these contracts. Thus, the CME Group offers options on corn futures, live cattle futures, and so on. Options exchanges exist all over the world (see the table at the end of this book).

The Over-the-Counter Market for Options

The over-the-counter market for options has grown very rapidly since the early 1980s and is now bigger than the exchange-traded market. One advantage of options traded in the over-the-counter market is that they can be tailored to meet the particular needs of a corporate treasurer or fund manager. For example, a corporate treasurer who wants a European call option to buy 1.6 million British pounds at an exchange rate of 1.5580 may not find exactly the right product trading on an exchange. However, it is likely that many derivatives dealers would be pleased to provide a quote for an over-the-counter contract that meets the treasurer's precise needs.

1.7 TYPES OF TRADER

Futures, forward, and options markets have been outstandingly successful. The main reason is that they have attracted many different types of trader and have a great deal of liquidity. When a trader wants to take one side of a contract, there is usually no problem in finding someone who is prepared to take the other side.

Three broad categories of trader can be identified: hedgers, speculators, and arbitrageurs. Hedgers use futures, forwards, and options to reduce the risk that they face from potential future movements in a market variable. Speculators use them to bet on the future direction of a market variable. Arbitrageurs take offsetting positions in two or more instruments to lock in a profit. As described in Business Snapshot 1.3, hedge funds have become big users of derivatives for all three purposes.

In the next few sections, we consider the activities of each type of trader in more detail.

1.8 HEDGERS

In this section we illustrate how hedgers can reduce their risks with forward contracts and options.

Hedging Using Forward Contracts

Suppose that it is May 13, 2015, and ImportCo, a company based in the United States, knows that it will have to pay £10 million on August 13, 2015, for goods it has purchased from a British supplier. The USD/GBP exchange rate quotes made by a financial institution are shown in Table 1.1. ImportCo could hedge its foreign exchange risk by buying pounds (GBP) from the financial institution in the three-month forward market at 1.5742. This would have the effect of fixing the price to be paid to the British exporter at $15,742,000.

Consider next another U.S. company, which we will refer to as ExportCo, that is exporting goods to the United Kingdom and on May 13, 2015, knows that it will receive £30 million three months later. ExportCo can hedge its foreign exchange risk by selling £30 million in the three-month forward market at an exchange rate of 1.5736. This would have the effect of locking in the U.S. dollars to be realized for the pounds at $47,208,000.

Business Snapshot 1.3 Hedge funds

Hedge funds have become major users of derivatives for hedging, speculation, and arbitrage. They are similar to mutual funds in that they invest funds on behalf of clients. However, they accept funds only from professional fund managers or financially sophisticated individuals and do not publicly offer their securities. Mutual funds are subject to regulations requiring that the shares be redeemable at any time, that investment policies be disclosed, that the use of leverage be limited, and so on. Hedge funds are relatively free of these regulations. This gives them a great deal of freedom to develop sophisticated, unconventional, and proprietary investment strategies. The fees charged by hedge fund managers are dependent on the fund's performance and are relatively high—typically 2 plus 20%, i.e., 2% of the amount invested plus 20% of the profits. Hedge funds have grown in popularity, with about $2 trillion being invested in them throughout the world. "Funds of funds" have been set up to invest in a portfolio of hedge funds.

The investment strategy followed by a hedge fund manager often involves using derivatives to set up a speculative or arbitrage position. Once the strategy has been defined, the hedge fund manager must:

1. Evaluate the risks to which the fund is exposed
2. Decide which risks are acceptable and which will be hedged
3. Devise strategies (usually involving derivatives) to hedge the unacceptable risks.

Here are some examples of the labels used for hedge funds together with the trading strategies followed:

Long/Short Equities: Purchase securities considered to be undervalued and short those considered to be overvalued in such a way that the exposure to the overall direction of the market is small.

Convertible Arbitrage: Take a long position in a thought-to-be-undervalued convertible bond combined with an actively managed short position in the underlying equity.

Distressed Securities: Buy securities issued by companies in, or close to, bankruptcy.

Emerging Markets: Invest in debt and equity of companies in developing or emerging countries and in the debt of the countries themselves.

Global Macro: Carry out trades that reflect anticipated global macroeconomic trends.

Merger Arbitrage: Trade after a possible merger or acquisition is announced so that a profit is made if the announced deal takes place.

Example 1.1 summarizes the hedging strategies open to ImportCo and ExportCo. Note that a company might do better if it chooses not to hedge than if it chooses to hedge. Alternatively, it might do worse. Consider ImportCo. If the exchange rate is 1.5000 on August 13 and the company has not hedged, the £10 million that it has to pay will cost $15,000,000, which is less than $15,742,000. On the other hand, if the exchange rate is 1.6000, the £10 million will cost $16,000,000—and the company will wish it had hedged! The position of ExportCo if it does not hedge is the reverse. If the exchange rate in August proves to be less than 1.5736, the company will wish it had hedged; if the rate is greater than 1.5736, it will be pleased it has not done so.

Example 1.1 Hedging with forward contracts

It is May 13, 2015. ImportCo must pay £10 million on August 13, 2015, for goods purchased from Britain. Using the quotes in Table 1.1, it buys £10 million in the three-month forward market to lock in an exchange rate of 1.5742 for the pounds it will pay.

ExportCo will receive £30 million on August 13, 2015, from a customer in Britain. Using quotes in Table 1.1, it sells £30 million in the three-month forward market to lock in an exchange rate of 1.5736 for the pounds it will receive.

This example illustrates a key aspect of hedging. Hedging reduces the risk, but it is not necessarily the case that the outcome with hedging will be better than the outcome without hedging.

Hedging Using Options

Options can also be used for hedging. Example 1.2 considers an investor who in May of a particular year owns 1,000 shares of a company. The share price is \$28 per share. The investor is concerned about a possible share price decline in the next two months and wants protection. The investor could buy 10 July put option contracts on the company's stock with a strike price of \$27.50. Each contract is on 100 shares. The position would therefore give the investor the right to sell a total of 1,000 shares for a price of \$27.50. If the quoted option price is \$1, each option contract would cost $100 \times \$1 = \$100$ and the total cost of the hedging strategy would be $10 \times \$100 = \$1{,}000$.

The strategy costs \$1,000 but guarantees that the shares can be sold for at least \$27.50 per share during the life of the option. If the market price of the stock falls below \$27.50, the options will be exercised so that \$27,500 is realized for the entire holding. When the cost of the options is taken into account, the amount realized is \$26,500. If the market price stays above \$27.50, the options are not exercised and expire worthless. However, in this case the value of the holding is always above \$27,500 (or above \$26,500 when the cost of the options is taken into account). Figure 1.4 shows the net value of the portfolio (after taking the cost of the options into account) as a function of the stock price in two months. The dotted line shows the value of the portfolio assuming no hedging.

Example 1.2 Hedging with options

It is May. An investor who owns 1,000 shares of a company and wants protection against a possible decline in the share price over the next two months. Market quotes are as follows:

Current share price: \$28
July 27.50 put price: \$1

The investor buys 10 put option contracts for a total cost of \$1,000. This gives the investor the right to sell 1,000 shares for \$27.50 per share during the next two months.

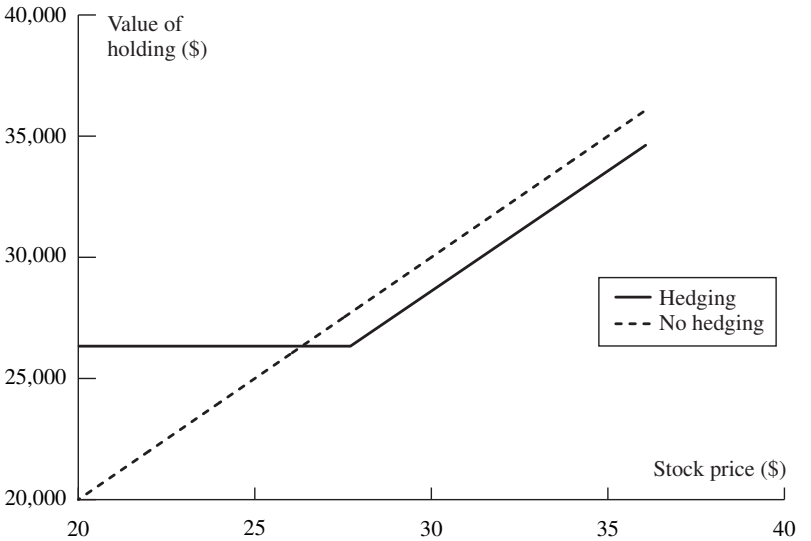

Figure 1.4 Value in Example 1.2 of the investor's holding in two months

A Comparison

There is a fundamental difference between the use of forward contracts and options for hedging. Forward contracts are designed to neutralize risk by fixing the price that the hedger will pay or receive for the underlying asset. Option contracts, by contrast, provide insurance. They offer a way for investors to protect themselves against adverse price movements in the future while still allowing them to benefit from favorable price movements. Unlike forwards, options involve the payment of an up-front fee.

1.9 SPECULATORS

We now move on to consider how futures and options markets can be used by speculators. Whereas hedgers want to avoid an exposure to adverse movements in the price of an asset, speculators wish to take a position in the market. Either they are betting that the price of the asset will go up or they are betting that it will go down.

Speculation Using Futures

Consider a U.S. speculator who in February thinks that the British pound will strengthen relative to the U.S. dollar over the next two months and is prepared to back that hunch to the tune of £250,000. One thing the speculator can do is purchase £250,000 in the spot market in the hope that the sterling can be sold later at higher price. (The sterling once purchased would be kept in an interest-bearing account.) Another possibility is to take a long position in four CME April futures contracts on sterling. (Each futures contract is for the purchase of £62,500.) Table 1.4 summarizes the two alternatives on the assumption that the current exchange rate is 1.5470 dollars

Table 1.4 Speculation using spot and futures contracts. One futures contract is on £62,500. Initial margin for four futures contracts = $20,000

	Possible Trade	
	Buy £250,000 *Spot price = 1.5470*	*Buy 4 futures contracts* *Futures price = 1.5410*
Investment	$386,750	$20,000
Profit if April spot = 1.6000	$13,250	$14,750
Profit if April spot = 1.5000	−$11,750	−$10,250

per pound and the April futures price is 1.5410 dollars per pound. If the exchange rate turns out to be 1.6000 dollars per pound in April, the futures contract alternative enables the speculator to realize a profit of $(1.6000 - 1.5410) \times 250{,}000 = \$14{,}750$. The spot market alternative leads to 250,000 units of an asset being purchased for $1.5470 in February and sold for $1.6000 in April, so that a profit of $(1.6000 - 1.5470) \times 250{,}000 = \$13{,}250$ is made. If the exchange rate falls to 1.5000 dollars per pound, the futures contract gives rise to a $(1.5410 - 1.5000) \times 250{,}000 = \$10{,}250$ loss, whereas the spot market alternative gives rise to a loss of $(1.5470 - 1.5000) \times 250{,}000 = \$11{,}750$. The alternatives appear to give rise to slightly different profits and losses, but these calculations do not reflect the interest that is earned or paid.

What then is the difference between the two alternatives? The first alternative of buying sterling requires an up-front investment of $386,750 (= 250,000 × 1.5470). By contrast, the second alternative requires only a small amount of cash—perhaps $20,000—to be deposited by the speculator in what is termed a margin account (this is explained in Chapter 2). The futures market allows the speculator to obtain leverage. With a relatively small initial outlay, a large speculative position can be taken.

Speculation Using Options

Options can also be used for speculation. Suppose that it is October and a speculator considers that a stock is likely to increase in value over the next two months. The stock price is currently $20, and a two-month call option with a $22.50 strike price is currently selling for $1. Table 1.5 illustrates two possible alternatives assuming that the speculator is willing to invest $2,000. One alternative is to purchase 100 shares.

Table 1.5 Comparison of profits from two alternative strategies for using $2,000 to speculate on a stock worth $20 in October

Speculator's strategy	*December stock price*	
	$15	*$27*
Buy 100 shares	−$500	$700
Buy 2,000 call options	−$2,000	$7,000

Another involves the purchase of 2,000 call options (i.e., 20 call option contracts). Suppose that the speculator's hunch is correct and the price of the stock rises to \$27 by December. The first alternative of buying the stock yields a profit of

$$100 \times (\$27 - \$20) = \$700$$

However, the second alternative is far more profitable. A call option on the stock with a strike price of \$22.50 gives a payoff of \$4.50, because it enables something worth \$27 to be bought for \$22.50. The total payoff from the 2,000 options that are purchased under the second alternative is

$$2{,}000 \times \$4.50 = \$9{,}000$$

Subtracting the original cost of the options yields a net profit of

$$\$9{,}000 - \$2{,}000 = \$7{,}000$$

The options strategy is, therefore, ten times more profitable than the strategy of buying the stock.

Options also give rise to a greater potential loss. Suppose the stock price falls to \$15 by December. The first alternative of buying stock yields a loss of

$$100 \times (\$20 - \$15) = \$500$$

Because the call options expire without being exercised, the options strategy would lead to a loss of \$2,000—the original amount paid for the options. Figure 1.5 shows the profit or loss from the two strategies as a function of the price of the stock in two months.

Options like futures provide a form of leverage. For a given investment, the use of options magnifies the financial consequences. Good outcomes become very good, while bad outcomes result in the whole initial investment being lost.

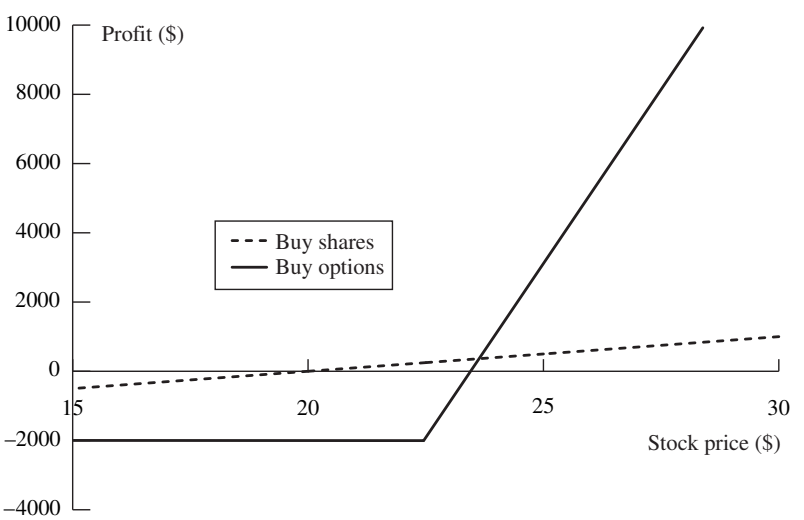

Figure 1.5 Profit or loss from two alternative strategies for speculating on a stock currently worth \$20

A Comparison

Futures and options are similar instruments for speculators in that they both provide a way in which a type of leverage can be obtained. However, there is an important difference between the two. When a speculator uses futures the potential loss as well as the potential gain is very large. When options are used, no matter how bad things get, the speculator's loss is limited to the amount paid for the options.

1.10 ARBITRAGEURS

Arbitrageurs are a third important group of participants in futures, forward, and options markets. Arbitrage involves locking in a riskless profit by simultaneously entering into transactions in two or more markets. In later chapters we will see how arbitrage is sometimes possible when the futures price of an asset gets out of line with its spot price. We will also examine how arbitrage can be used in options markets. This section illustrates the concept of arbitrage with a very simple example.

Example 1.3 considers a stock that is traded in both New York and London. Suppose that the stock price is \$152 in New York and £100 in London at a time when the exchange rate is \$1.5500 per pound. An arbitrageur could simultaneously buy 100 shares of the stock in New York and sell them in London to obtain a risk-free profit of

$$100 \times [(\$1.55 \times 100) - \$152]$$

or \$300 in the absence of transactions costs. Transactions costs would probably eliminate the profit for a small trader. However, a large investment bank faces very low transactions costs in both the stock market and the foreign exchange market. It would find the arbitrage opportunity very attractive and would try to take as much advantage of it as possible.

Arbitrage opportunities such as the one in Example 1.3 cannot last for long. As arbitrageurs buy the stock in New York, the forces of supply and demand will cause the

Example 1.3 An arbitrage opportunity

A stock is traded in both New York and London. The following quotes have been obtained:

New York: \$152 per share
London: £100 per share
Value of £1: \$1.5500

A trader does the following:

1. Buys 100 shares in New York
2. Sells the shares in London
3. Converts the sale proceeds from pounds to dollars.

This leads to a profit of

$$100 \times [(\$1.55 \times 100) - \$152] = \$300$$

dollar price to rise. Similarly, as they sell the stock in London, the sterling price will be driven down. Very quickly the two prices will become equivalent at the current exchange rate. Indeed, the existence of profit-hungry arbitrageurs makes it unlikely that a major disparity between the sterling price and the dollar price could ever exist in the first place. Generalizing from this example, we can say that the very existence of arbitrageurs means that in practice only very small arbitrage opportunities are observed in the prices that are quoted in most financial markets. In this book most of the arguments concerning futures prices, forward prices, and the values of option contracts will be based on the assumption that there are no arbitrage opportunities.

1.11 DANGERS

Derivatives are very versatile instruments. As we have seen they can be used for hedging, for speculation, and for arbitrage. It is this very versatility that can cause problems. Sometimes traders who have a mandate to hedge risks or follow an arbitrage strategy become (consciously or unconsciously) speculators. The results can be disastrous. One example of this is provided by the activities of Jérôme Kerviel at Société Général (see Business Snapshot 1.4).

To avoid the type of problems Société Général encountered it is very important for both financial and nonfinancial corporations to set up controls to ensure that derivatives are being used for their intended purpose. Risk limits should be set and the activities of traders should be monitored daily to ensure that the risk limits are adhered to.

Unfortunately, even when traders follow the risk limits that have been specified, big mistakes can happen. Some of the activities of traders in the derivatives market during the period leading up to the start of the credit crisis in July 2007 proved to be much riskier than they were thought to be by the financial institutions they worked for. As will be discussed in Chapter 8, house prices in the United States had been rising fast. Most people thought that the increases would continue—or, at worst, that house prices would simply level off. Very few were prepared for the steep decline that actually happened. Furthermore, very few were prepared for the high correlation between mortgage default rates in different parts of the country. Some risk managers did express reservations about the exposures of the companies for which they worked to the U.S. real estate market. But, when times are good (or appear to be good), there is an unfortunate tendency to ignore risk managers and this is what happened at many financial institutions during the 2006–2007 period. The key lesson from the credit crisis is that financial institutions should always be dispassionately asking "What can go wrong?", and they should follow that up with the question "If it does go wrong, how much will we lose?"

SUMMARY

In this chapter we have taken a first look at futures, forward, and options markets. Futures and forward contracts are agreements to buy or sell an asset at a certain time in the future for a certain price. Futures contracts are traded on an exchange, whereas forward contracts are traded in the over-the-counter market. There are two types of

Business Snapshot 1.4 SocGen's big loss in 2008

Derivatives are very versatile instruments. They can be used for hedging, speculation, and arbitrage. One of the risks faced by a company that trades derivatives is that an employee who has a mandate to hedge or to look for arbitrage opportunities may become a speculator.

Jérôme Kerviel joined Société Général (SocGen) in 2000 to work in the compliance area. In 2005, he was promoted and became a junior trader in the bank's Delta One products team. He traded equity indices such as the German DAX index, the French CAC 40, and the Euro Stoxx 50. His job was to look for arbitrage opportunities. These might arise if a futures contract on an equity index was trading for a different price on two different exchanges. They might also arise if equity index futures prices were not consistent with the prices of the shares constituting the index. (This type of arbitrage is discussed in Chapter 5.)

Kerviel used his knowledge of the bank's procedures to speculate while giving the appearance of arbitraging. He took big positions in equity indices and created fictitious trades to make it appear that he was hedged. In reality, he had large bets on the direction in which the indices would move. The size of his unhedged position grew over time to tens of billions of euros.

In January 2008, his unauthorized trading was uncovered by SocGen. Over a three-day period, the bank unwound his position for a loss of 4.9 billion euros. This was at the time the biggest loss created by fraudulent activity in the history of finance. (Later in the year, a much bigger loss from Bernard Madoff's Ponzi scheme came to light.)

Rogue trader losses were not unknown at banks prior to 2008. For example, in the 1990s, Nick Leeson, who worked at Barings Bank, had a mandate similar to that of Jérôme Kerviel. His job was to arbitrage between Nikkei 225 futures quotes in Singapore and Osaka. Instead he found a way to make big bets on the direction of the Nikkei 225 using futures and options, losing $1 billion and destroying the 200-year old bank in the process. In 2002, it was found that John Rusnak at Allied Irish Bank had lost $700 million from unauthorized foreign exchange trading. The lessons from these losses are that it is important to define unambiguous risk limits for traders and then to monitor what they do very carefully to make sure that the limits are adhered to.

options: calls and puts. A call option gives the holder the right to buy an asset by a certain date for a certain price. A put option gives the holder the right to sell an asset by a certain date for a certain price. Options trade both on exchanges and in the over-the-counter market.

Futures, forwards, and options have been very successful innovations. Three main types of participants in the markets can be identified: hedgers, speculators, and arbitrageurs. Hedgers are in the position of facing risk associated with the price of an asset. They use futures, forward, or option contracts to reduce or eliminate this risk. Speculators wish to bet on future movements in the price of an asset. Futures, forward, and option contracts can give them extra leverage; that is, the contracts can increase both the potential gains and potential losses in a speculative investment. Arbitrageurs are in business to take advantage of a discrepancy between prices in two different markets. If, for example, they see the futures price of an asset getting out of line with the spot price, they will take offsetting positions in the two markets to lock in a profit.

FURTHER READING

Chancellor, E. *Devil Take the Hindmost—A History of Financial Speculation*. New York: Farra Straus Giroux, 2000.

Merton, R. C. "Finance Theory and Future Trends: The Shift to Integration," *Risk*, 12, 7 (July 1999): 48–51.

Miller, M. H. "Financial Innovation: Achievements and Prospects," *Journal of Applied Corporate Finance*, 4 (Winter 1992): 4–11.

Zingales, L. "Causes and Effects of the Lehman Bankruptcy," Testimony before Committee on Oversight and Government Reform, United States House of Representatives, October 6, 2008.

Quiz (Answers at End of Book)

1.1. What is the difference between a long futures position and a short futures position?

1.2. Explain carefully the difference between (a) hedging, (b) speculation, and (c) arbitrage.

1.3. What is the difference between (a) entering into a long futures contract when the futures price is \$50 and (b) taking a long position in a call option with a strike price of \$50?

1.4. An investor enters into a short forward contract to sell 100,000 British pounds for U.S. dollars at an exchange rate of 1.5000 U.S. dollars per pound. How much does the investor gain or lose if the exchange rate at the end of the contract is (a) 1.4900 and (b) 1.5200?

1.5. Suppose that you write a put contract with a strike price of \$40 and an expiration date in three months. The current stock price is \$41 and one put option contract is on 100 shares. What have you committed yourself to? How much could you gain or lose?

1.6. You would like to speculate on a rise in the price of a certain stock. The current stock price is \$29 and a three-month call with a strike price of \$30 costs \$2.90. You have \$5,800 to invest. Identify two alternative strategies. Briefly outline the advantages and disadvantages of each.

1.7. What is the difference between the over-the-counter and the exchange-traded market? What are the bid and offer quotes of a market maker in the over-the-counter market?

Practice Questions (Answers in Solutions Manual/Study Guide)

1.8. Suppose you own 5,000 shares that are worth \$25 each. How can put options be used to provide you with insurance against a decline in the value of your holding over the next four months?

1.9. A stock when it is first issued provides funds for a company. Is the same true of an exchange-traded stock option? Discuss.

1.10. Explain why a futures contract can be used for either speculation or hedging.

1.11. A cattle farmer expects to have 120,000 pounds of live cattle to sell in three months. The live-cattle futures contract on the Chicago Mercantile Exchange is for the delivery of 40,000 pounds of cattle. How can the farmer use the contract for hedging? From the farmer's viewpoint, what are the pros and cons of hedging?

1.12. It is July 2016. A mining company has just discovered a small deposit of gold. It will take six months to construct the mine. The gold will then be extracted on a more or less continuous basis for one year. Futures contracts on gold are available on the New York Mercantile Exchange. There are delivery months every two months from August 2016 to December 2017. Each contract is for the delivery of 100 ounces. Discuss how the mining company might use futures markets for hedging.

1.13. Suppose that a March call option on a stock with a strike price of $50 costs $2.50 and is held until March. Under what circumstances will the holder of the option make a gain? Under what circumstances will the option be exercised? Draw a diagram showing how the profit on a long position in the option depends on the stock price at the maturity of the option.

1.14. Suppose that a June put option on a stock with a strike price of $60 costs $4 and is held until June. Under what circumstances will the holder of the option make a gain? Under what circumstances will the option be exercised? Draw a diagram showing how the profit on a short position in the option depends on the stock price at the maturity of the option.

1.15. It is May and a trader writes a September call option with a strike price of $20. The stock price is $18 and the option price is $2. Describe the trader's cash flows if the option is held until September and the stock price is $25 at this time.

1.16. An investor writes a December put option with a strike price of $30. The price of the option is $4. Under what circumstances does the investor make a gain?

1.17. The CME Group offers a futures contract on long-term Treasury bonds. Characterize the traders likely to use this contract.

1.18. An airline executive has argued: "There is no point in our using oil futures. There is just as much chance that the price of oil in the future will be less than the futures price as there is that it will be greater than this price." Discuss the executive's viewpoint.

1.19. "Options and futures are zero-sum games." What do you think is meant by this statement?

1.20. A trader enters into a short forward contract on 100 million yen. The forward exchange rate is $0.0080 per yen. How much does the trader gain or lose if the exchange rate at the end of the contract is (a) $0.0074 per yen; (b) $0.0091 per yen?

1.21. A trader enters into a short cotton futures contract when the futures price is 50 cents per pound. The contract is for the delivery of 50,000 pounds. How much does the trader gain or lose if the cotton price at the end of the contract is (a) 48.20 cents per pound; (b) 51.30 cents per pound?

1.22. A company knows that it is due to receive a certain amount of a foreign currency in four months. What type of option contract is appropriate for hedging?

1.23. A company in the United States expects to have to pay 1 million Canadian dollars in six months. Explain how the exchange rate risk can be hedged using (a) a forward contract; (b) an option.

1.24. A trader buys a call option with a strike price of $30 for $3. Does the trader ever exercise the option and lose money on the trade. Explain.

1.25. A trader sells a put option with a strike price of $40 for $5. What is the trader's maximum gain and maximum loss? How does your answer change if it is a call option?

1.26. "Buying a put option on a stock when the stock is owned is a form of insurance." Explain this statement.

Further Questions

1.27. Trader A enters into a forward contract to buy an asset for $1,000 in one year. Trader B buys a call option to buy the asset for $1,000 in one year. The cost of the option is $100. What is the difference between the positions of the traders? Show the profit as a function of the price of the asset in one year for the two traders.

1.28. On May 13, 2015, as indicated in Table 1.2, the spot offer price of Google stock is $532.34 and the offer price of a call option with a strike price of $525 and a maturity date of September is $30.40. A trader is considering two alternatives: buy 100 shares of the stock and buy 100 September call options. For each alternative, what is (a) the upfront cost, (b) the total gain if the stock price in September is $600, and (c) the total loss if the stock price in September is $500. Assume that the option is not exercised before September and if stock is purchased it is sold in September.

1.29. What is arbitrage? Explain the arbitrage opportunity when the price of a dually listed mining company stock is $50 (USD) on the New York Stock Exchange and $60 (CAD) on the Toronto Stock Exchange. Assume that the exchange rate is such that 1 USD equals 1.18 CAD. Explain what is likely to happen to prices as traders take advantage of this opportunity.

1.30. In March, a U.S. investor instructs a broker to sell one July put option contract on a stock. The stock price is $42 and the strike price is $40. The option price is $3. Explain what the investor has agreed to. Under what circumstances will the trade prove to be profitable? What are the risks?

1.31. A U.S. company knows it will have to pay 3 million euros in three months. The current exchange rate is 1.1500 dollars per euro. Discuss how forward and options contracts can be used by the company to hedge its exposure.

1.32. A stock price is $29. An investor buys one call option contract on the stock with a strike price of $30 and sells a call option contract on the stock with a strike price of $32.50. The market prices of the options are $2.75 and $1.50, respectively. The options have the same maturity date. Describe the investor's position.

1.33. The price of gold is currently $1,200 per ounce. Forward contracts are available to buy or sell gold at $1,400 per ounce for delivery in one year. An arbitrageur can borrow money at 5% per annum. What should the arbitrageur do? Assume that the cost of storing gold is zero and that gold provides no income.

1.34. Discuss how foreign currency options can be used for hedging in the situation described in Example 1.1 so that (a) ImportCo is guaranteed that its exchange rate will be less than 1.5900, and (b) ExportCo is guaranteed that its exchange rate will be at least 1.5500.

1.35. The current price of a stock is $94, and three-month European call options with a strike price of $95 currently sell for $4.70. An investor who feels that the price of the stock will increase is trying to decide between buying 100 shares and buying 2,000 call options (20 contracts). Both strategies involve an investment of $9,400. What advice would you give? How high does the stock price have to rise for the option strategy to be more profitable?

1.36. On May 13, 2015, an investor owns 100 Google shares. As indicated in Table 1.3, the bid share price is $532.20 and a December put option with a strike price of $500 costs $22.10. The investor is comparing two alternatives to limit downside risk. The first involves

buying one December put option contract with a strike price of $500. The second involves instructing a broker to sell the 100 shares as soon as Google's price reaches $500. Discuss the advantages and disadvantages of the two strategies.

1.37. A trader buys a European call option and sells a European put option. The options have the same underlying asset, strike price, and maturity. Describe the trader's position. Under what circumstances does the price of the call equal the price of the put?

CHAPTER 2

Futures Markets and Central Counterparties

In Chapter 1 we explained that both futures and forward contracts are agreements to buy or sell an asset at a future time for a certain price. Futures contracts are traded on an exchange and the contract terms are standardized by that exchange. Forward contracts are traded in the over-the-counter market and can be customized to meet the needs of end users.

This chapter covers the details of how futures markets work. We examine issues such as the specification of contracts, the operation of margin accounts, the organization of exchanges, the regulation of markets, how quotes are made, and the treatment of futures transactions for accounting and tax purposes. We explain how some of the ideas pioneered by futures exchanges are now being adopted by over-the-counter markets.

2.1 OPENING AND CLOSING FUTURES POSITIONS

A futures contract is an agreement to buy or sell an asset for a certain price at a certain time in the future. A contract is usually referred to by its delivery month. Thus a trader could instruct a broker to buy one October oil futures contract. There is a period of time during the delivery month (often the whole month) when delivery can be made. Trading in the contract usually ceases some time during the delivery period. The party with the short position chooses when delivery is made.

The reader may be surprised to learn that the vast majority of the futures contracts that are initiated do not lead to delivery. The reason is that most traders choose to close out their positions prior to the delivery period specified in the contract. Making or taking delivery under the terms of a futures contract is often inconvenient and in some instances quite expensive. This is true even for a hedger who wants to buy or sell the asset underlying the futures contract. Such a hedger usually prefers to close out the futures position and then buy or sell the asset in the usual way.

Closing a position involves entering into an opposite trade to the original one that opened the position. For example, a trader who buys five July corn futures contracts on May 6 can close out the position on June 20 by selling (i.e., shorting) five July corn futures contracts. A trader who sells (i.e., shorts) five July contracts on May 6 can close out the position on June 20 by buying five July contracts. In each case, the trader's

total gain or loss is determined by the change in the futures price between May 6 and June 20.

Delivery is so unusual that traders sometimes forget how the delivery process works (see Business Snapshot 2.1). Nevertheless we will review delivery arrangements later in this chapter. This is because it is the possibility of final delivery that ties the futures price to the spot price.[1]

2.2 SPECIFICATION OF A FUTURES CONTRACT

When developing a new contract, the exchange must specify in some detail the exact nature of the agreement between the two parties. In particular, it must specify the asset, the contract size (exactly how much of the asset will be delivered under one contract), where delivery can be made, and when delivery can be made.

Sometimes alternatives are specified for the grade of the asset that will be delivered or for the delivery locations. As a general rule, it is the party with the short position (the party that has agreed to sell the asset) that chooses what will happen when alternatives are specified by the exchange.[2] When the party with the short position is ready to deliver, it files a *notice of intention to deliver* with the exchange. This notice indicates any selections it has made with respect to the grade of asset that will be delivered and the delivery location.

The Asset

When the asset is a commodity, there may be quite a variation in the quality of what is available in the marketplace. When the asset is specified, it is therefore important that the exchange stipulate the grade or grades of the commodity that are acceptable. The IntercontinentalExchange (ICE) has specified the asset in its orange juice futures contract as frozen concentrates that are U.S. Grade A, with Brix value of not less than 62.5 degrees.

For some commodities a range of grades can be delivered, but the price received depends on the grade chosen. For example, in the CME Group corn futures contract, the standard grade is "No. 2 Yellow," but substitutions are allowed with the price being adjusted in a way established by the exchange. No. 1 Yellow is deliverable for 1.5 cents per bushel more than No. 2 Yellow. No. 3 Yellow is deliverable for 1.5 cents per bushel less than No. 2 Yellow.

The financial assets in futures contracts are generally well defined and unambiguous. For example, there is no need to specify the grade of a Japanese yen. However, there are some interesting features of the Treasury bond and Treasury note futures contracts traded by the CME Group. The underlying asset in the Treasury bond contract is any U.S. Treasury bond that has a maturity between 15 and 25 years on the first day of the delivery month. In the 10-year Treasury note futures contract, the underlying asset is any Treasury note with a maturity between 6.5 and 10 years on the first day of the

[1] As mentioned in Chapter 1, the spot price is the price for almost immediate delivery.

[2] There are exceptions. As pointed out by J. E. Newsome, G. H. K. Wang, M. E. Boyd, and M. J. Fuller in "Contract Modifications and the Basis Behavior of Live Cattle Futures," *Journal of Futures Markets*, 24, 6 (2004), 557–90, the CME gave the buyer some options on how delivery could be made in live cattle futures in 1995.

Business Snapshot 2.1 The unanticipated delivery of a futures contract

This story (which may well be apocryphal) was told to the author of this book a long time ago by a senior executive of a financial institution. It concerns a new employee of the financial institution who had not previously worked in the financial sector. One of the clients of the financial institution regularly entered into a long futures contract on live cattle for hedging purposes and issued instructions to close out the position on the last day of trading. (Live cattle futures contracts are traded by the CME Group and each contract is on 40,000 pounds of cattle.) The new employee was given responsibility for handling the account.

When the time came to close out a contract, the employee noted that the client was long one contract and instructed a trader at the exchange to buy (not sell) one contract. The result of this mistake was that the financial institution ended up with a long position in two live cattle futures contracts. By the time the mistake was spotted, trading in the contract had ceased.

The financial institution (not the client) was responsible for the mistake. As a result it started to look into the details of the delivery arrangements for live cattle futures contracts—something it had never done before. Under the terms of the contract, cattle could be delivered by the party with the short position to a number of different locations in the United States during the delivery month. Because it was long, the financial institution could do nothing but wait for a party with a short position to issue a *notice of intention to deliver* to the exchange and for the exchange to assign that notice to the financial institution.

It eventually received a notice from the exchange and found that it would receive live cattle at a location 2,000 miles away the following Tuesday. The new employee was sent to the location to handle things. It turned out that the location had a cattle auction every Tuesday. The party with the short position that was making delivery bought cattle at the auction and then immediately delivered them. Unfortunately the cattle could not be resold until the next cattle auction the following Tuesday. The employee was therefore faced with the problem of making arrangements for the cattle to be housed and fed for a week. This was a great start to a first job in the financial sector!

delivery month.. In both cases, the exchange has a formula for adjusting the price received according to the coupon and maturity date of the bond delivered. This is discussed in Chapter 6.

The Contract Size

The contract size specifies the amount of the asset that has to be delivered under one contract. This is an important decision for the exchange. If the contract size is too large, many traders who wish to hedge relatively small exposures or who wish to take relatively small speculative positions will be unable to use the exchange. On the other hand, if the contract size is too small, trading may be expensive as there is a cost associated with each contract traded.

The correct size for a contract clearly depends on the likely user. Whereas the value of what is delivered under a futures contract on an agricultural product might be $10,000 to $20,000, it is much higher for some financial futures. For example, under the

Treasury bond futures contract traded by the CME Group, instruments with a face value of $100,000 are delivered.

In some cases exchanges have introduced "mini" contracts to attract smaller traders. For example, the CME Group's Mini Nasdaq 100 contract is on 20 times the Nasdaq 100 index whereas the regular contract is on 100 times the index. (We will cover futures on indices more fully in Chapter 3.)

Delivery Arrangements

The place where delivery will be made must be specified by the exchange. This is particularly important for commodities that involve significant transportation costs. In the case of the ICE frozen concentrate orange juice contract, delivery is to exchange-licensed warehouses in Florida, New Jersey, or Delaware.

When alternative delivery locations are specified, the price received by the party with the short position is sometimes adjusted according to the location chosen by that party. The price tends to be higher for delivery locations that are relatively far from the main sources of the commodity.

Delivery Months

A futures contract is referred to by its delivery month. The exchange must specify the precise period during the month when delivery can be made. For many futures contracts, the delivery period is the whole month.

The delivery months vary from contract to contract and are chosen by the exchange to meet the needs of market participants. For example, corn futures traded by the CME Group have delivery months of March, May, July, September, and December. At any given time, contracts trade for the closest delivery month and a number of subsequent delivery months. The exchange specifies when trading in a particular month's contract will begin. The exchange also specifies the last day on which trading can take place for a given contract. Trading generally ceases a few days before the last day on which delivery can be made.

Price Quotes

The exchange defines how prices will be quoted. For example, crude oil futures prices are quoted in dollars and cents; Treasury bond and Treasury note futures prices are quoted in dollars and thirty-seconds of a dollar.

Price Limits and Position Limits

For most contracts, daily price movement limits are specified by the exchange. If in a day the price moves down from the previous day's close by an amount equal to the daily price limit, the contract is said to be *limit down*. If it moves up by the limit, it is said to be *limit up*. A *limit move* is a move in either direction equal to the daily price limit. Normally, trading ceases for the day once the contract is limit up or limit down. However, in some instances the exchange has the authority to step in and change the limits.

The purpose of daily price limits is to prevent large price movements from occurring because of speculative excesses. However, limits can become an artificial barrier to

trading when the price of the underlying commodity is advancing or declining rapidly. Whether price limits are, on balance, good for futures markets is controversial.

Position limits are the maximum number of contracts that a speculator may hold. The purpose of these limits is to prevent speculators from exercising undue influence on the market.

2.3 CONVERGENCE OF FUTURES PRICE TO SPOT PRICE

As the delivery period for a futures contract is approached, the futures price converges to the spot price of the underlying asset. When the delivery period is reached, the futures price equals, or is very close to the spot price.

To see why this is so, we first suppose that the futures price is above the spot price during the delivery period. Traders then have a clear arbitrage opportunity:

1. Sell (i.e., short) a futures contract
2. Buy the asset
3. Make delivery

These steps are certain to lead to a profit equal to the amount by which the futures price exceeds the spot price. As traders exploit this arbitrage opportunity, the futures price will fall. Suppose next that the futures price is below the spot price during the delivery period. Companies interested in acquiring the asset will find it attractive to buy a futures contract and then wait for delivery to be made. As they do so, the futures price will tend to rise.

The result is that the futures price is very close to the spot price during the delivery period. Figure 2.1 illustrates the convergence of the futures price to the spot price. In Figure 2.1a the futures price is above the spot price prior to the delivery period, and in Figure 2.1b the futures price is below the spot price prior to the delivery period. The circumstances under which these two patterns are observed are discussed in Chapter 5.

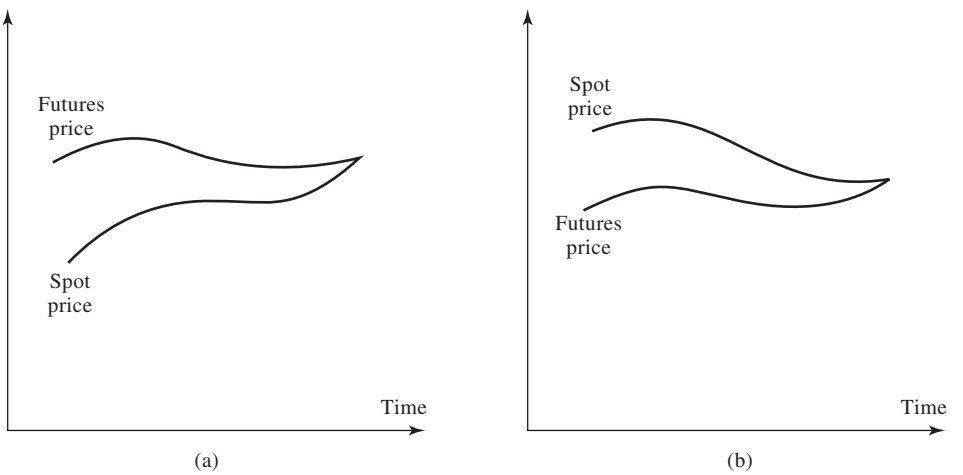

Figure 2.1 Relationship between futures price and spot price as the delivery month is approached: (a) futures price above spot price; (b) futures price below spot price

2.4 THE OPERATION OF MARGIN ACCOUNTS

If two investors get in touch with each other directly and agree to trade an asset in the future for a certain price, there are obvious risks. One of the investors may regret the deal and try to back out. Alternatively, the investor simply may not have the financial resources to honor the agreement. One of the key roles of the exchange is to organize trading so that contract defaults are avoided. This is where margin accounts come in.

Daily Settlement

To illustrate how margin accounts work, we consider an investor who contacts his or her broker to buy two December gold futures contracts. We suppose that the current futures price is \$1,250 per ounce. Because the contract size is 100 ounces, the investor has contracted to buy a total of 200 ounces at this price. The broker will require the investor to deposit funds in a *margin account*. The amount that must be deposited at the time the contract is entered into is known as the *initial margin*. We suppose this is \$6,000 per contract, or \$12,000 in total. At the end of each trading day, the margin account is adjusted to reflect the investor's gain or loss. This practice is referred to as *daily settlement* or *marking to market*.

Suppose, for example, that by the end of the first day the futures price has dropped from \$1,250 to \$1,241. The investor has a loss of \$1,800 ($= 200 \times \$9$), because the 200 ounces of December gold, which the investor contracted to buy at \$1,250, can now be sold for only \$1,241. The balance in the margin account would therefore be reduced by \$1,800 to \$10,200. Similarly, if the price of December gold rose to \$1,259 by the end of the first day, the balance in the margin account would be increased by \$1,800 to \$13,800. A trade is first settled at the close of the day on which it takes place. It is then settled at the close of trading on each subsequent day.

Note that daily settlement is not merely an arrangement between broker and client. When there is a decrease in the futures price so that the margin account of an investor with a long position is reduced by \$1,800, the investor's broker has to pay the exchange clearing house \$1,800 and this money is passed on to the broker of an investor with a short position. Similarly, when there is an increase in the futures price, brokers for parties with short positions pay money to the exchange clearing house and brokers for parties with long positions receive money from the exchange clearing house. Later we will examine in more detail the mechanism by which this happens.

The investor is entitled to withdraw any balance in the margin account in excess of the initial margin. To ensure that the balance in the margin account never becomes negative, a *maintenance margin*, which is somewhat lower than the initial margin, is set. If the balance in the margin account falls below the maintenance margin, the investor receives a margin call and is expected to top up the margin account to the initial margin level the next day. The extra funds deposited are known as a *variation margin*. If the investor does not provide the variation margin, the broker closes out the position. In the case considered above, closing out the position would involve neutralizing the existing contract by selling 200 ounces of gold for delivery in December.

Table 2.1 illustrates the operation of the margin account for one possible sequence of futures prices in the case of the investor considered earlier. The maintenance margin is assumed for the purpose of the illustration to be \$4,500 per contract, or \$9,000 in total. On Day 7 the balance in the margin account falls \$1,020 below the maintenance margin

Table 2.1 Operation of margin account for a long position in two gold futures contracts. The initial margin is \$6,000 per contract, or \$12,000 in total; the maintenance margin is \$4,500 per contract, or \$9,000 in total. The contract is entered into on Day 1 at \$1,250 and closed out on Day 16 at \$1,226.90

Day	*Trade price (\$)*	*Settlement price (\$)*	*Daily gain (\$)*	*Cumulative gain (\$)*	*Margin account balance (\$)*	*Margin call (\$)*
1	1,250.00				12,000	
1		1,241.00	−1,800	−1,800	10,200	
2		1,238.30	−540	−2,340	9,660	
3		1,244.60	1,260	−1,080	10,920	
4		1,241.30	−660	−1,740	10,260	
5		1,240.10	−240	−1,980	10,020	
6		1,236.20	−780	−2,760	9,240	
7		1,229.90	−1,260	−4,020	7,980	4,020
8		1,230.80	180	−3,840	12,180	
9		1,225.40	−1,080	−4,920	11,100	
10		1,228.10	540	−4,380	11,640	
11		1,211.00	−3,420	−7,800	8,220	3,780
12		1,211.00	0	−7,800	12,000	
13		1,214.30	660	−7,140	12,660	
14		1,216.10	360	−6,780	13,020	
15		1,223.00	1,380	−5,400	14,400	
16	1,226.90		780	−4,620	15,180	

level. This drop triggers a margin call from the broker for additional \$4,020 to bring the margin account balance up to \$12,000. Table 2.1 assumes that the investor does in fact provide this margin by the close of trading on Day 8. On Day 11 the balance in the margin account again falls below the maintenance margin level, and a margin call for \$3,780 is sent out. The investor provides this margin by the close of trading on Day 12. On Day 16 the investor decides to close out the position by selling two contracts. The futures price on that day is \$1,226.90, and the investor has a cumulative loss of \$4,620. Note that the investor has excess margin on Days 8, 13, 14, and 15. Table 2.1 assumes that the excess is not withdrawn.

Further Details

Most brokers pay investors interest on the balance in a margin account. The balance in the account does not, therefore, represent a true cost, providing the interest rate is competitive with what could be earned elsewhere. To satisfy the initial margin requirements (but not subsequent margin calls), an investor can usually deposit securities with the broker. Treasury bills are usually accepted in lieu of cash at about 90% of their face value. Shares are also sometimes accepted in lieu of cash—but at about 50% of their market value.

Whereas a forward contract is settled at the end of its life, a futures contract is settled daily. At the end of each day, the investor's gain (loss) is added to (subtracted from) the margin account, bringing the value of the contract back to zero. A futures contract is in effect closed out and rewritten at a new price each day.

Minimum levels for the initial and maintenance margin are set by the exchange clearing house. Individual brokers may require more margin from their clients than the minimum level specified by the exchange clearing house. Minimum margin levels are determined by the variability of the price of the underlying asset and are revised when necessary. The higher the variability, the higher the margin levels. The maintenance margin is usually about 75% of the initial margin.

Margin requirements may depend on the objectives of the trader. A bona fide hedger, such as a company that produces the commodity on which the futures contract is written, is often subject to lower margin requirements than a speculator. The reason is that there is deemed to be less risk of default. Day trades and spread transactions often give rise to lower margin requirements than do hedge transactions. In a *day trade* the trader announces to the broker an intent to close out the position in the same day. In a *spread transaction* the trader simultaneously buys (i.e., takes a long position in) a contract on an asset for one maturity month and sells (i.e., takes a short position in) a contract on the same asset for another maturity month.

Note that margin requirements are the same on short futures positions as they are on long futures positions. It is just as easy to take a short futures position as it is to take a long one. The spot market does not have this symmetry. Taking a long position in the spot market involves buying the asset for immediate delivery and presents no problems. Taking a short position involves selling an asset that you do not own. This is a more complex transaction that may or may not be possible in a particular market. It is discussed further in Chapter 5.

The Clearing House and Its Members

A *clearing house* acts as an intermediary in futures transactions. It guarantees the performance of the parties to each transaction. The clearing house has a number of members. Brokers who are not members themselves must channel their business through a member and post margin with the member. The main task of the clearing house is to keep track of all the transactions that take place during a day so that it can calculate the net position of each of its members.

The clearing house member is required to provide to the clearing house initial margin (sometimes referred to as clearing margin) reflecting the total number of contracts that are being cleared. There is no maintenance margin applicable to the clearing house member. At the end of each day, the transactions of the clearing house member are settled through the clearing house. If in total the transactions have lost money, the member is required to provide variation margin to the exchange clearing house (usually by the beginning of the next day); if there has been a gain on the transactions, the member receives variation margin from the clearing house. Intraday variation margin payments may also be required by a clearing house from its members in times of significant price volatility or changes in position.

In determining the margin requirement for a member, the number of contracts outstanding is usually calculated on a net basis. This means that the short positions the clearing house member is handling for clients are offset against long positions. Suppose, for example, that the clearing house member has two clients: one with a long position in 20 contracts, the other with a short position in 15 contracts. The initial margin would be calculated on the basis of 5 contracts. The calculation of the margin requirement is usually designed to ensure that it is 99% certain to cover any losses in

the event that the member defaults and has to be closed out. Clearing house members are required to contribute to a guaranty fund. This may be used by the clearing house in the event that a member defaults and its margin proves insufficient to cover losses.

Credit Risk

The whole purpose of the margining system is to ensure that funds are available to pay traders when they make a profit. Overall the system has been very successful. Traders entering into contracts at major exchanges have always had their contracts honored. Futures markets were tested on October 19, 1987, when the S&P 500 index declined by over 20% and traders with long positions in S&P 500 futures found they had negative margin balances with their brokers. Traders who did not meet margin calls were closed out but still owed their brokers money. Some did not pay, and as a result some brokers went bankrupt because, without their clients' money, they were unable to meet margin calls on contracts they had entered into on behalf of their clients. However, the clearing house had sufficient funds to ensure that everyone who had a short futures position on the S&P 500 got paid.

2.5 OTC MARKETS

Over-the-counter (OTC) markets, introduced in Chapter 1, are markets where companies agree to derivatives transactions without involving an exchange. Credit risk has traditionally been a feature of OTC derivatives markets. Consider two companies, A and B, that have entered into a number of derivatives transactions. If A defaults when the net value of the outstanding transactions to B is positive, a loss is likely to be taken by B. Similarly, if B defaults when the net value of outstanding transactions to A is positive, a loss is likely to be taken by company A. In an attempt to reduce credit risk, the OTC market has borrowed some ideas from exchange-traded markets. We now discuss this.

Central Counterparties

We briefly mentioned CCPs in Section 1.2. These are clearing houses for standard OTC transactions that perform much the same role as exchange clearing houses. Members of the CCP, similarly to members of an exchange clearing house, have to provide both initial margin and daily variation margin. Like members of an exchange clearing house, they are also required to contribute to a guaranty fund.

Once an OTC derivative transaction has been agreed between two parties A and B, it can be presented to a CCP. Assuming the CCP accepts the transaction, it becomes the counterparty to both A and B. (This is similar to the way the clearing house for a futures exchange becomes the counterparty to the two sides of a futures trade.) For example, if the transaction is a forward contract where A has agreed to buy an asset from B in one year for a certain price. The clearing house agrees to:

1. Buy the asset from B in one year for the agreed price, and
2. Sell the asset to A in one year for the agreed price.

It takes on the credit risk of both A and B.

All members of the CCP are required to provide initial margin to the CCP. Transactions are valued daily. This leads to variation margin payments. If an OTC market participant is not itself a member of a CCP, it can arrange to clear its trades through a CCP member. It will then have to provide margin to the CCP member. Its relationship with the CCP member is similar to the relationship between a broker and a futures exchange clearing house member.

Following the credit crisis that started in 2007, regulators have become more concerned about systemic risk (see Business Snapshot 1.2). One result of this, mentioned in Section 1.2, has been legislation requiring that most standard OTC transactions between financial institutions be handled by CCPs.

Bilateral Clearing

Those OTC transactions that are not cleared through CCPs are cleared bilaterally. In the bilaterally cleared OTC market, two companies A and B usually enter into a master agreement covering all their trades.[3] This agreement often includes an annex, referred to as the credit support annex or CSA, requiring A or B, or both, to provide collateral. The collateral is similar to the margin required by exchange clearing houses or CCPs from their members.

Collateral agreements in CSAs usually require transactions to be valued each day. A simple two-way agreement between companies A and B might work as follows. If, from one day to the next, the transactions between A and B increase in value to A by X (and therefore decrease in value to B by X), B is required to provide X of collateral to A. If the reverse happens and the transactions increase in value to B by X (and decrease in value to A by X), A is required to provide X to B. (To use the terminology of exchange-traded markets, X is the variation margin provided.)

It has traditionally been relatively rare for a CSA to require initial margin. This is changing. Beginning in 2016, regulations require both initial margin and variation margin to be provided for bilaterally cleared transactions between financial institutions.[4] The initial margin will typically be segregated from other funds and posted with a third party.

Collateral significantly reduces credit risk in the bilaterally cleared OTC market (and will do so even more as a result of rules requiring initial margin for transactions between financial institutions). Collateral agreements were used by the hedge fund Long-Term Capital Management (LTCM) for its bilaterally cleared derivatives in the 1990s. The agreements allowed LTCM to be highly levered. They did provide credit protection, but as described in Business Snapshot 2.2, the high leverage left the hedge fund exposed to other risks.

Figure 2.2 illustrates the way bilateral and central clearing work. (It makes the simplifying assumption that there are only eight market participants and one CCP.) Under bilateral clearing there are many different agreements between market participants, as indicated in Figure 2.2a. If all OTC contracts were cleared through a single

[3] The most common such agreement is an International Swaps and Derivatives Association (ISDA) Master Agreement.

[4] For both this regulation and the regulation requiring standard transactions between financial institutions to be cleared through CCPs, "financial institutions" include banks, insurance companies, pension funds and hedge funds. Transactions with nonfinancial institutions and some foreign exchange transactions are exempt from the regulations.

Business Snapshot 2.2 Long-Term Capital Management's big loss

Long-Term Capital Management (LTCM), a hedge fund formed in the mid-1990s, always collateralized its transactions. The hedge fund's investment strategy was known as convergence arbitrage. A very simple example of what it might do is the following. It would find two bonds, X and Y, issued by the same company that promised the same payoffs, with X being less liquid (i.e., less actively traded) than Y. The market places a value on liquidity. As a result the price of X would be less than the price of Y. LTCM would buy X, short Y, and wait, expecting the prices of the two bonds to converge at some future time.

When interest rates increased, the company expected both bonds to move down in price by about the same amount so that the collateral it paid on bond X would be about the same as the collateral it received on bond Y. Similarly, when interest rates decreased LTCM expected both bonds to move up in price by about the same amount so that the collateral it received on bond X would be about the same as the collateral it paid on bond Y. It therefore expected that there would be no significant outflow of funds as a result of its collateralization agreements.

In August 1998, Russia defaulted on its debt and this led to what is termed a "flight to quality" in capital markets. One result was that investors valued liquid instruments more highly than usual and the spreads between the prices of the liquid and illiquid instruments in LTCM's portfolio increased dramatically. The prices of the bonds LTCM had bought went down and the prices of those it had shorted increased. It was required to post collateral on both. The company experienced difficulties because it was highly leveraged. Positions had to be closed out and LTCM lost about $4 billion. If the company had been less highly leveraged, it would probably have been able to survive the flight to quality and could have waited for the prices of the liquid and illiquid bonds to move back closer to each other.

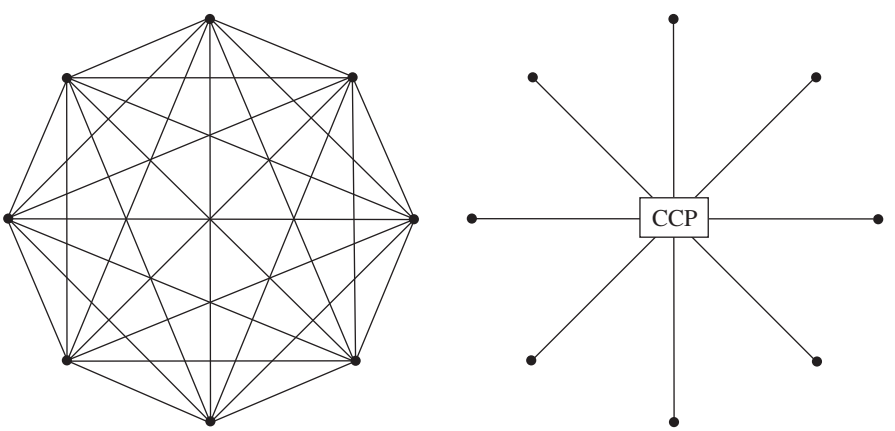

Figure 2.2 (a) The traditional way in which OTC markets have operated: a series of bilateral agreements between market participants; (b) how OTC markets would operate with a single central counterparty.

CCP, we would move to the situation shown in Figure 2.2b. In practice, because not all OTC transaction are routed through CCPs and there is more than one CCP, the market has elements of both Figure 2.2a and 2.2b.[5]

Futures Trades vs. OTC Trades

Regardless of how transactions are cleared, initial margin when provided in the form of cash usually earns interest. The daily variation margin provided by clearing house members for futures contracts does not earn interest. This is because the variation margin constitutes the daily settlement. Transactions in the OTC market, whether cleared through CCPs or cleared bilaterally, are usually not settled daily. For this reason, the daily variation margin that is provided by the member of a CCP or, as a result of a CSA, earns interest when it is in the form of cash.

Securities can often be used to satisfy margin/collateral requirements.[6] The market value of the securities is reduced by a certain amount to determine their value for margin purposes. This reduction is known as a *haircut*.

2.6 MARKET QUOTES

Futures quotes are available from exchanges and several online sources. Table 2.2 is constructed from quotes provided by the CME Group for a number of different commodities at a particular time on May 13, 2015. Quotes for index, currency, and interest rate futures are given in Chapters 3, 5, and 6, respectively.

The asset underlying the futures contract, the contract size, and the way the price is quoted are shown at the top of each section of Table 2.2. The first asset is gold. The contract size is 100 ounces and the price is quoted as dollars per ounce. The maturity month of the contract is indicated in the first column of the table.

Prices

The first three numbers in each row of Table 2.2 show the opening price, the highest price in trading so far during the day, and the lowest price in trading so far during the day. The opening price is representative of the prices at which contracts were trading immediately after the start of trading on May 13, 2015. For the June 2015 gold contract, the opening price on May 13, 2015 was $1,192.5 per ounce. The highest price during the day was $1,218.5 per ounce and the lowest price during the day was $1,190.4 per ounce.

Settlement Price

The *settlement price* is the price used for calculating daily gains and losses and margin requirements. It is usually calculated as the price at which the contract traded immediately before the end of a day's trading session. The fourth number in Table 2.2

[5] The impact of CCPs on credit risk depends on the number of CCPs and proportions of all trades that are cleared through them. See D. Duffie and H. Zhu, "Does a Central Clearing Counterparty Reduce Counterparty Risk? *Review of Asset Pricing Studies*, 1 (2011): 74–95.

[6] As already mentioned, the variation margin for futures contracts must be provided in the form of cash.

Table 2.2 Futures quotes for a selection of CME Group contracts on commodities on May 13, 2015

	Open	*High*	*Low*	*Prior settlement*	*Last trade*	*Change*	*Volume*
Gold, 100 oz, $ per oz							
June 2015	1192.5	1218.5	1190.4	1192.4	1214.4	+22.0	221,244
Aug. 2015	1194.1	1219.4	1191.5	1193.4	1215.4	+22.0	29,683
Oct. 2015	1194.2	1220.2	1193.0	1194.3	1216.0	+21.7	1,194
Dec. 2015	1194.0	1221.2	1193.9	1195.3	1217.3	+22.0	5,404
June 2016	1209.0	1219.0	1209.0	1198.0	1219.0	+21.0	31
Crude Oil, 1,000 barrels, $ per barrel							
June 2015	61.23	61.85	60.19	60.75	60.20	−0.55	379,797
Sept. 2015	63.30	63.49	62.03	62.58	62.03	−0.55	39,663
Dec. 2015	64.22	64.39	63.05	63.58	63.05	−0.53	54,902
Dec. 2016	65.82	65.99	64.86	65.48	64.91	−0.57	20,212
Dec. 2017	66.86	67.08	66.25	66.83	66.25	−0.58	3,087
Corn, 5,000 bushels, cents per bushel							
July 2015	360.25	363.75	357.25	361.00	362.25	+1.25	203,068
Sept. 2015	366.00	369.25	363.00	366.00	368.25	+2.25	84,255
Dec. 2015	376.00	380.00	373.50	376.00	378.50	+2.50	105,216
Mar. 2016	387.25	391.00	384.75	387.50	389.50	+2.00	13,791
May 2016	393.50	398.75	392.50	395.25	397.50	+2.25	2,329
July 2016	399.75	405.00	398.75	401.50	404.00	+2.50	2,904
Soybeans, 5,000 bushels, cents per bushel							
July 2015	956.50	962.75	954.25	955.50	957.50	+2.00	104,851
Sept. 2015	941.00	942.50	934.75	936.00	938.50	+2.50	3,710
Nov. 2015	931.25	938.50	928.50	930.75	934.75	+4.00	53,126
Jan. 2016	937.50	944.75	935.50	937.00	941.75	+4.75	3,356
Mar. 2016	943.25	950.25	941.00	942.25	947.00	+4.75	2,023
May 2016	947.00	953.25	944.75	945.75	950.75	+5.00	1,576
Wheat, 5,000 bushels, cents per bushel							
July 2015	480.75	486.50	471.00	480.50	481.75	+1.25	67,036
Sept. 2015	488.00	493.00	478.00	487.50	488.25	+0.75	16,902
Dec. 2015	504.00	510.00	494.50	504.50	505.00	+0.50	15,001
Mar. 2016	521.75	524.50	511.50	520.75	522.00	+1.25	2,447
May 2016	531.50	535.00	522.00	531.25	531.50	+0.25	581
Live Cattle, 40,000 lbs, cents per lb							
June 2015	151.250	152.425	150.825	151.475	152.325	+0.850	26,813
Aug. 2015	149.450	150.850	148.975	149.650	150.850	+1.200	19,806
Oct. 2015	150.650	152.150	150.350	150.775	152.025	+1.250	8,397
Dec. 2015	151.575	153.150	151.500	151.725	153.000	+1.275	4,821
Feb. 2016	152.125	153.225	151.700	152.025	153.000	+0.975	1,029