Fundamentals of
FUTURES AND OPTIONS MARKETS

EIGHTH EDITION

JOHN C. HULL

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To My Students

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Preface

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

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

What's New in This Edition?

Many changes have been made to update material and improve the presentation. For example:

1. The changes taking place in the way over-the-counter derivatives are traded are explained. These changes are significant and most instructors will want to talk about them in their classes.
2. Chapter 7 on swaps reflects the trend in the market toward OIS discounting. It explains how swaps can be valued using both LIBOR and OIS discounting. It is becoming increasingly important for students to understand this material.
3. New nontechnical explanations of the Black–Scholes–Merton formula are provided in Chapter 13 and an appendix to Chapter 12 outlines how the formula can be derived from binomial trees. Many users of the book have asked for these changes.
4. New material has been added on principal protected notes (Chapter 11) reflecting their importance in the market.
5. Products such as DOOM options and CEBOs offered by the CME Group are covered (Chapter 9) because I find students enjoy learning about them.
6. The material on exotic options (Chapter 22) has been expanded to include a discussion of cliquet and Parisian options. I find students also enjoy learning about these products.

7. The material on credit derivatives (Chapter 23) has been updated and expanded. Several instructors have asked for this.
8. Value at risk is explained with an example using real data (Chapter 20). The example and accompanying spread sheets have been improved for this edition. This makes the presentation more interesting and gives instructors the opportunity to use richer assignment questions.
9. Many new end-of-chapter problems have been added.
10. The Test Bank available to adopting instructors has been expanded and improved.

Slides

Several hundred PowerPoint slides can be downloaded from my website or from Pearson's Instructor Resource Center. Instructors adopting the book are welcome to adapt the slides to meet their own needs.

Software

DerivaGem, Version 2.01, 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 a wide range of options. 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.

A version of the software's functions that is compatible with Open Office for Mac and Linux users is provided. Users can now access the code for the functions underlying DerivaGem.

The software is described more fully at the end of the book and a "Getting Started" section is now included. Updates to the software can be downloaded from my website:

www.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 0-13-299514-X), which is published by Pearson and can be purchased separately from this book.

Instructors Manual

The *Instructors Manual* is made available online by Pearson to adopting instructors. It contains solutions to further questions, notes on the teaching of each chapter and on course organization, and some relevant Excel worksheets.

Test Bank

The Test Bank has been greatly improved for this edition and is also available online from Pearson to adopting instructors.

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 and Lorraine Lin provided excellent research assistance.

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 my editor Katie Rowland, the editor-in-chief Donna Battista, and the project managers Alison Eusden and Emily Biberger. I welcome comments on the book from readers. My email address is:

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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 specifying how trading must be done, how trades must be reported, and the collateral that must be provided.

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. The Chicago Board of Trade, the Chicago Mercantile Exchange, and the New York Mercantile Exchange have merged to form the CME Group (www.cmegroup.com). Other large exchanges include NYSE Euronext (www.euronext.com), Eurex (www.eurexchange.com), BM&FBOVESPA (www.bmfbovespa.com.br), and the Tokyo Financial Exchange (www.tfx.co.jp). 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,

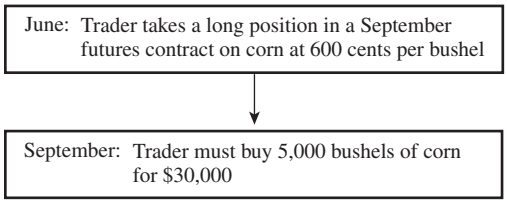

Figure 1.1 A futures contract (assuming it is held to maturity)

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 600 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 600 cents per bushel in September and the trader in Kansas has agreed to sell 5,000 bushels of corn for 600 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 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. In undertaking this storage, the company does not bear any price risk, but does incur the costs of storage. If the farmer or some other person stores the corn, the company and the storer 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 is now part of the CME Group.

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.

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 investor in New York who wanted to buy September corn and another floor trader would represent the investor 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 filing 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 hundreds of thousands of 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. It is easy to see that sorting out who owes what to whom in this type of situation is a nightmare!

Exchanges have largely replaced the open outcry system by *electronic trading*. This involves traders entering their required trades at a keyboard and a computer being used to match buyers and sellers. Most futures exchanges throughout the world are entirely electronic. Electronic trading has led to a growth in algorithmic trading, also known as black-box, automated, high-frequency, or robo trading. This involves 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.

Traditionally, participants in the OTC derivatives markets have contacted each other

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.

directly or have found counterparties for their trades using an interdealer broker. Banks often act as market makers for the more commonly traded instruments. This means that they are always prepared to quote a bid price (at which they are prepared to take one side of a derivatives transaction) and an offer price (at which they are prepared to take the other side). When they start trading with each other, two market participants often sign an agreement covering all transactions they might enter into in the future. The issues covered in the agreement include the circumstances under which outstanding transactions can be terminated, how settlement amounts are calculated in the event of a termination, and how the collateral (if any) that must be posted by each side is calculated.

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 many new regulations affecting the operation of OTC markets. The purpose of the regulations is to improve the transparency of OTC markets, improve market efficiency, 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 in the United States must whenever possible be traded on what are referred to as *swap execution facilities* (SEFs). These are platforms where market participants can post bid and offer quotes and where they can choose to trade by accepting the quotes of other market participants.
2. There is a requirement in most parts of the world that a central clearing party (CCP) be used for most standardized derivatives transactions. 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 registry.

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,

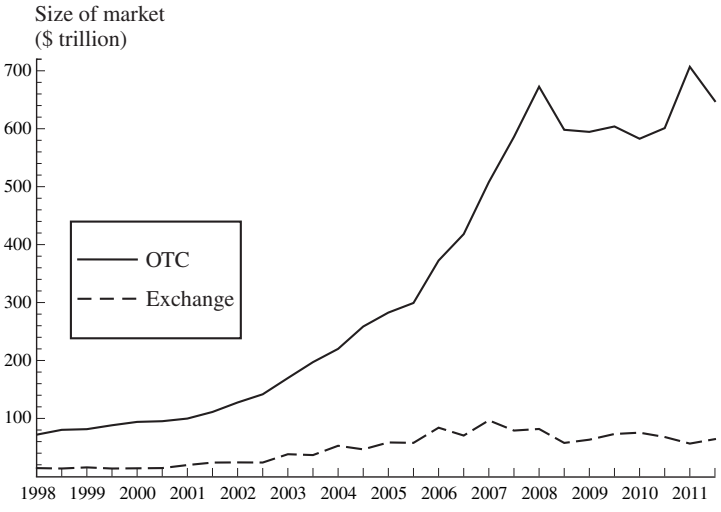

Figure 1.2 Size of over-the-counter and exchange-traded derivatives markets

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 between 1998 and 2011 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 $648 trillion in December 2011 and that of the exchange-traded market was $64 trillion at this time.

In interpreting these numbers 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 2011 to be about $27 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

[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, June 22, 2012 (GBP = British pound; USD = U.S. dollar; quote is number of USD per GBP)

	Bid	*Offer*
Spot	1.5585	1.5589
1-month forward	1.5582	1.5587
3-month forward	1.5579	1.5585
6-month forward	1.5573	1.5580

future time. Table 1.1 provides the 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 June 22, 2012. 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 $1.5585 per GBP and sell sterling in the spot market at $1.5589 per GBP. The second row indicates that the bank is prepared to buy sterling in one month at $1.5582 per GBP and sell sterling in one month at $1.5587 per GBP; the third row indicates that it is prepared to buy sterling in three months at $1.5579 per GBP and sell sterling in three months at $1.5585 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 $155.73 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, an

Table 1.2. Prices of call options on Google, June 25, 2012; stock price: bid $561.32; offer $561.51

Strike price	*July 2012*		*Sept. 2012*		*Dec. 2012*	
($)	*Bid*	*Offer*	*Bid*	*Offer*	*Bid*	*Offer*
520	46.50	47.20	55.40	56.80	67.70	70.00
540	31.70	32.30	41.60	42.50	55.30	56.20
560	20.00	20.40	30.20	30.70	44.20	45.00
580	11.30	11.60	20.70	21.20	34.50	35.30
600	5.60	5.90	13.50	13.90	26.30	27.10

investor must pay an up-front price, known as the *option premium*, for an option contract.

The largest exchange in the world for trading stock options is the Chicago Board Options Exchange (CBOE; www.cboe.com). Table 1.2 gives the bid and offer quotes for some of the call options trading on Google (ticker symbol: GOOG) on June 25, 2012. 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 561.32, offer 561.51. The bid–offer spread on an option, as a percentage of its price, is greater than that on the underlying stock and depends on the volume of trading. The option strike prices in the tables are $520, $540, $560, $580, and $600. The maturities are July 2012, September 2012, and December 2012. The July options have a maturity date of July 21, 2012, the September options have a maturity date of September 22, 2012, and the December options have a maturity date of December 22, 2012.

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 an investor instructs a broker to buy one December call option contract on Google with a strike price of $580. The broker will relay these instructions to a trader at the CBOE and the deal will be done. The (offer) price is $35.30, 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, June 25, 2012; stock price: bid $561.32; offer $561.51

Strike price	*July 2012*		*Sept. 2012*		*Dec. 2012*	
($)	*Bid*	*Offer*	*Bid*	*Offer*	*Bid*	*Offer*
520	5.00	5.30	13.60	14.00	25.30	26.10
540	10.20	10.50	19.80	20.30	32.80	33.50
560	18.30	18.70	28.10	28.60	41.50	42.30
580	29.60	30.00	38.40	39.10	51.80	52.60
600	43.80	44.40	51.10	52.10	63.50	64.90

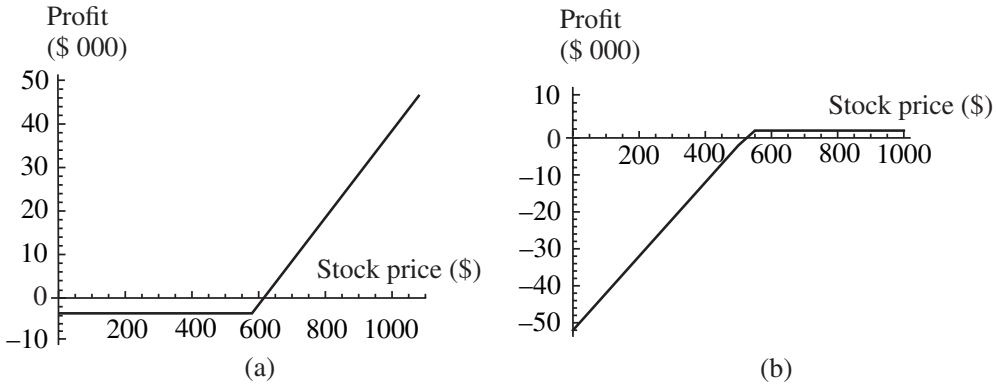

Figure 1.3 Net profit from (a) purchasing a contract consisting of 100 Google December call options with a strike price of $580 and (b) selling a contract consisting of 100 Google September put options with a strike price of $540

option contract is an agreement to buy or sell 100 shares. Therefore, the investor must arrange for $3,530 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 investor has obtained at a cost of $3,530 the right to buy 100 Google shares for $580 each. If the price of Google does not not rise above $580.00 by December 22, 2012, the option is not exercised and the investor loses $3,530.[2] But if Google does well and the option is exercised when the bid price for the stock is $650, the investor is able to buy 100 shares at $580 and immediately sell them for $650 for a profit of $7,000—or $3,470 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 $540 at the bid price of $19.80. This would lead to an immediate cash inflow of $\$100 \times 19.80 = \$1{,}980$. If the Google stock price stays above $540, this option is not exercised and the investor makes a $1,980 profit. However, if stock price falls and the option is exercised when the stock price is $500 there is a loss. The investor must buy 100 shares at $540 when they are worth only $500. This leads to a loss of $4,000, or $2,020 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 investor'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 investor.

[3] The calculations here ignore the effect of discounting. Theoretically, the $7,000 should be discounted from the time of exercise to June 25, 2012 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. Investors 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 with investors. 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.i-seoptions.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 an investor 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 June 22, 2012, and ImportCo, a company based in the United States, knows that it will have to pay £10 million on September 22, 2012, 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 1.5585. This would have the effect of fixing the price to be paid to the British exporter at $15,585,000.

Consider next another U.S. company, which we will refer to as ExportCo, that is exporting goods to the United Kingdom and on June 22, 2012, 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 1.5579. This would have the effect of locking in the U.S. dollars to be realized for the pounds at $46,737,000.

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 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 September 22 and the company has not hedged, the £10 million that it has to pay will cost $15,000,000, which is less than $15,585,000. 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 September proves to be less than 1.5579, the company will wish it had hedged; if the rate is greater than 1.5579, it will be pleased it has not done so.

Example 1.1 Hedging with forward contracts

It is June 22, 2012. ImportCo must pay £10 million on September 22, 2012, 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 1.5585 for the pounds it will pay.

ExportCo will receive £30 million on September 22, 2012, 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 1.5579 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 on the Chicago Board Options Exchange with a strike price of $27.50. This would 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.

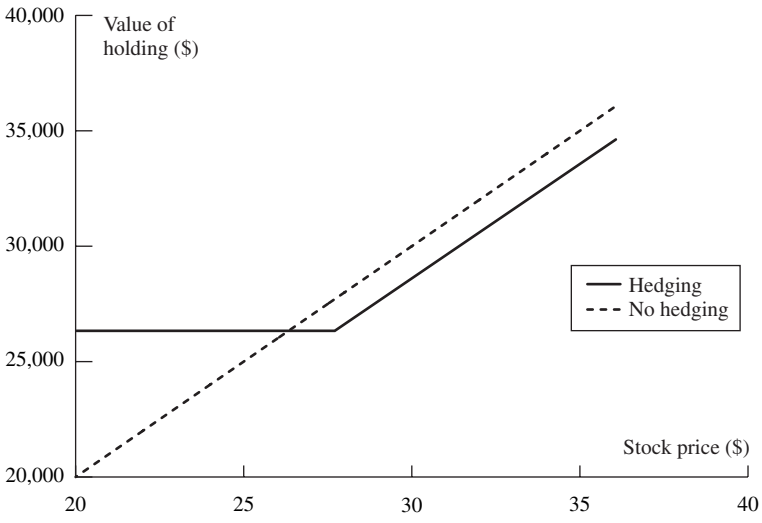

Figure 1.4 Value in Example 1.2 of the investor's holding in two months

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, the investor is able to take a large speculative position.

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

Investor'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.

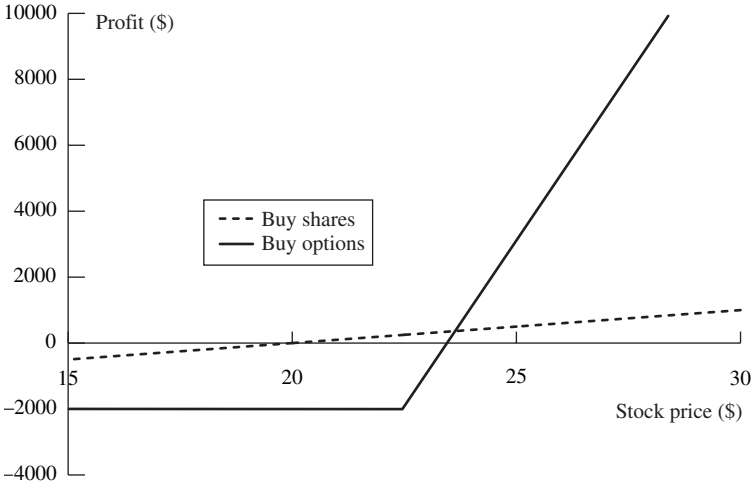

Figure 1.5 Profit or loss from two alternative strategies for speculating on a stock currently worth \$20

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 investor. 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 US 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

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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.

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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 1.4000 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) 1.3900 and (b) 1.4200?

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 2013. 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 2013 to December 2014. 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 investor'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 investors 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 United States company 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 stock and a put option on the stock 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 June 25, 2012, as indicated in Table 1.2, the spot offer price of Google stock is \$561.51 and the offer price of a call option with a strike price of \$560 and a maturity date of September is \$30.70. 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 \$620, 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 \$52 (CAD) on the Toronto Stock Exchange. Assume that the exchange rate is such that 1 USD equals 1.01 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 1.4500 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 \$1,800 per ounce. Forward contracts are available to buy or sell gold at \$2,000 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 1.5800, and (b) ExportCo is guaranteed that its exchange rate will be at least 1.5400.

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 June 25, 2012, an investor owns 100 Google shares. As indicated in Table 1.3, the bid share price is \$561.32 and a December put option with a strike price of \$520 costs \$26.10. The investor is comparing two alternatives to limit downside risk. The first involves

buying one December put option contract with a strike price of $520. The second involves instructing a broker to sell the 100 shares as soon as Google's price reaches $520. 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

Mechanics of Futures Markets

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.

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, the way in which 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 an investor 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 investors 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, an investor 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. An investor 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

investor'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 spend part of this chapter reviewing the delivery arrangements in futures contracts. 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 will be made, and when delivery will 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 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 investors 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 investors. 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, in the U.S., crude oil futures prices are quoted in dollars and cents, but 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.

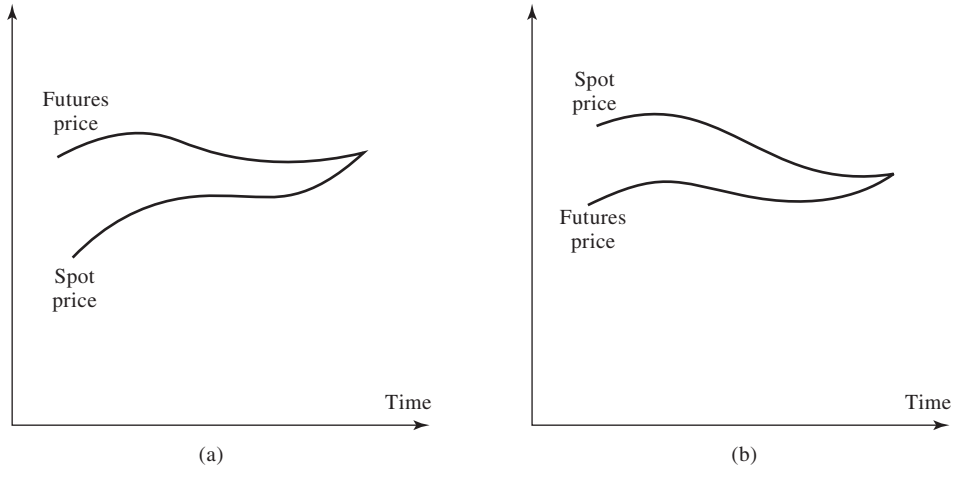

Figure 2.1 Relationship between futures price and spot price as the delivery month is approached: (a) futures price above spot price; (b) futures price below spot price

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 on June 5 to buy two December gold futures contracts. We suppose that the current futures price is \$1,650 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 June 5 the futures price has dropped from \$1,650 to \$1,641. The investor has a loss of \$1,800 (= 200 × \$9), because the 200 ounces of December gold, which the investor contracted to buy at \$1,650, can now be sold for only \$1,641. 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 \$1,659 by the end of June 5, 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 \$1,650 and closed out on Day 16 at \$1,626.90

Day	*Trade price (\$)*	*Settlement price (\$)*	*Daily gain (\$)*	*Cumulative gain (\$)*	*Margin account balance (\$)*	*Margin call (\$)*
1	1,650.00				12,000	
1		1,641.00	−1,800	−1,800	10,200	
2		1,638.30	−540	−2,340	9,660	
3		1,644.60	1,260	−1,080	10,920	
4		1,641.30	−660	−1,740	10,260	
5		1,640.10	−240	−1,980	10,020	
6		1,636.20	−780	−2,760	9,240	
7		1,629.90	−1,260	−4,020	7,980	4,020
8		1,630.80	180	−3,840	12,180	
9		1,625.40	−1,080	−4,920	11,100	
10		1,628.10	540	−4,380	11,640	
11		1,611.00	−3,420	−7,800	8,220	3,780
12		1,611.00	0	−7,800	12,000	
13		1,614.30	660	−7,140	12,660	
14		1,616.10	360	−6,780	13,020	
15		1,623.00	1,380	−5,400	14,400	
16	1,626.90		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 \$1,626.90, 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 Clearing Margin

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, who must contribute to a default fund. Brokers who are not members themselves must channel their business through a 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.

Just as an investor is required to maintain a margin account with a broker, the broker is required to maintain margin with a clearing house member and the clearing house member is required to maintain a margin account with the clearing house. The latter is known as a *clearing margin*. The margin accounts for clearing house members are adjusted for gains and losses at the end of each trading day in the same way as are the margin accounts of investors. However, in the case of the clearing house member, there is an original margin, but no maintenance margin. Every day the account balance for each contract must be maintained at an amount equal to the original margin times the number of contracts outstanding. Thus, depending on transactions during the day and price movements, the clearing house member may have to add funds to its margin account at the end of the day, or it may find it can remove funds from the account at this time. Brokers who are not clearing house members must maintain a margin account with a clearing house member.

In determining a clearing margin, the exchange clearing house calculates the number of contracts outstanding on either a gross or a net basis. When the gross basis is used,

the number of contracts equals the sum of long and short positions; when the net basis is used, these are offset against each other. Suppose a clearing house member has two clients: one with a long position in 20 contracts, the other with a short position in 15 contracts. Gross margining would calculate the clearing margin on the basis of 35 contracts; net margining would calculate the clearing margin on the basis of 5 contracts. Most exchanges currently use net margining.

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. 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 liable 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 A.

In an attempt to reduce credit risk, the OTC market has used some of the procedures of exchange-traded markets. The agreement between company A and company B may require A or B, or both, to post margin. (In this case of OTC markets, margin is referred to as collateral.) Also, as mentioned in Section 1.3, A and B may use a central clearing party, which is similar to an exchange clearing house, for its transactions. We will now explain these developments.

Collateral

Consider again two companies, A and B, that have entered into a number of OTC derivatives transactions. A collateral agreement between the companies is likely to involve the transactions being valued each day. The agreement may be one-way, where only one side is liable to have to post collateral, or two-way, where both sides are liable to have to post collateral. Many different types of collateral arrangements can be negotiated. A simple two-way agreement might work as follows. If from one day to the next the transactions increase in value to A by $\$X$ (and decrease in value to B by $\$X$), company 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 $\$X$),

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.

company A is required to provide $\$X$ to B. To use the terminology of exchange-traded markets, in this arrangement the companies would be required to post variation margin, but no initial margin.

The collateral can be in the form of cash or acceptable marketable securities. Interest is usually paid on cash collateral. The market value of securities is usually reduced by a certain percentage amount to determine their value for collateral purposes. This reduction is known as a *haircut*.

Collateralization significantly reduces the credit risk in over-the-counter contracts. Collateralization agreements were used by a hedge fund, Long-Term Capital Management (LTCM) in the 1990s. They allowed LTCM to be highly levered. The contracts did provide credit risk protection, but as described in Business Snapshot 2.2 the high leverage left the hedge fund vulnerable to other risks.

The Use of Clearing Houses in OTC Markets

Prior to the credit crisis that started in 2007, most OTC trades were handled by bilateral agreements between market participants.[3] As just described, the agreements often

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

involved collateral being posted, but the amount of collateral required was not usually as great as the amount of margin that would be required for similar transactions in the exchange-traded market. As a result, whereas exchange-traded markets were almost completely free of credit risk, OTC markets were not.

Following the credit crisis that started in 2007, regulators have become more concerned about systemic risk (see Business Snapshot 1.2). This has led them to look for ways reducing credit risk by making the OTC markets more like exchange-traded markets. The result has been legislation requiring that standard OTC transactions (with a few exceptions) be handled by what are known as *central clearing parties* (CCPs).

CCPs are similar to exchange clearing houses. Once it has been agreed between two parties A and B, a standard OTC derivative transaction is 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. It manages this risk by requiring an initial margin and a daily variation margin from each of them.

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 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.

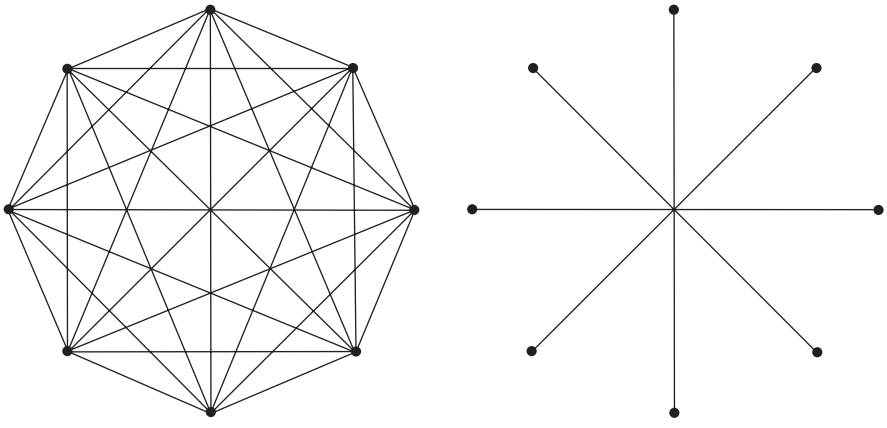

Figure 2.2 (a) The traditional way in which OTC markets have operated: a series of bilateral agreements between market participants; (b) how OTC markets would operate with a single central clearing house.

Table 2.2 Futures quotes for a selection of CME Group contracts on commodities on July 13, 2012

	Open	*High*	*Low*	*Prior settlement*	*Last trade*	*Change*	*Volume*
Gold, 100 oz, $ per oz							
Aug. 2012	1571.2	1596.5	1565.6	1565.3	1589.7	+24.4	115,296
Sept. 2012	1570.4	1597.5	1567.1	1566.4	1590.2	+23.8	303
Oct. 2012	1574.0	1598.3	1570.0	1567.6	1593.6	+26.0	726
Dec. 2012	1576.5	1601.0	1570.7	1570.0	1596.0	+26.0	11,283
June 2013	1598.0	1604.6	1598.0	1576.1	1604.6	+28.5	250
Crude Oil, 1,000 barrels, $ per barrel							
Aug. 2012	85.86	87.61	85.58	86.08	87.28	+1.20	223,698
Sept. 2012	86.33	88.00	85.95	86.46	87.68	+1.22	87,931
Dec. 2012	87.45	89.21	87.39	87.73	88.94	+1.21	31,701
Dec. 2013	88.85	90.15	88.78	88.92	89.95	+1.03	11,128
Dec. 2014	87.20	87.74	87.20	86.98	87.74	+0.76	2,388
Corn, 5,000 bushels, cents per bushel							
Sept. 2012	730.00	748.00	726.50	731.25	742.25	+11.00	78,317
Dec. 2012	731.25	749.00	727.25	732.25	742.25	+10.00	179,010
Mar. 2013	733.00	748.25	729.00	734.50	743.50	+9.00	22,588
May 2013	731.00	744.25	726.75	732.75	739.75	+7.00	4,548
July 2013	728.00	739.00	721.00	728.75	733.50	+4.75	7,874
Dec. 2013	618.75	626.50	613.75	618.25	626.00	+7.75	4,260
Soybeans, 5,000 bushels, cents per bushel							
Aug. 2012	1572.00	1600.00	1571.50	1572.50	1596.00	+23.50	19,194
Sept. 2012	1544.50	1574.00	1544.50	1545.50	1570.00	+24.50	7,024
Nov. 2012	1528.00	1561.50	1526.50	1529.00	1552.75	+23.75	98,526
Jan. 2013	1527.75	1557.25	1523.75	1526.00	1548.00	+22.00	11,621
Mar. 2013	1486.25	1508.00	1482.25	1481.25	1500.25	+19.00	6,226
May 2013	1432.25	1453.25	1428.00	1430.25	1449.00	+18.75	5,234
Wheat, 5,000 bushels, cents per bushel							
Sept. 2012	845.75	865.75	842.00	846.75	846.25	−0.50	41,301
Dec. 2012	859.00	877.75	856.00	859.75	861.50	+1.75	29,450
Mar. 2013	868.00	885.75	865.00	869.00	870.00	+2.00	6,972
May 2013	865.00	881.00	863.00	864.50	867.00	+2.50	2,339
July 2013	824.50	840.00	824.25	826.75	832.50	+5.75	4,118
Live Cattle, 40,000 lbs, cents per lb							
Aug. 2012	116.900	117.600	116.300	117.025	117.225	+0.200	23,117
Oct. 2012	121.450	121.650	120.525	121.650	121.600	−0.050	18,427
Dec. 2012	124.900	125.000	124.050	124.975	124.950	−0.025	6,561
Feb. 2013	128.500	128.500	127.525	128.550	128.500	−0.050	2,450
Apr. 2013	131.225	131.400	130.300	131.375	131.250	−0.125	1,615

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 July 13, 2012. 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 July 13, 2012. For the August 2012 gold contract, the opening price on July 13, 2012 was \$1,571.2 per ounce. The highest price during the day was \$1,596.5 per ounce and the lowest price during the day was \$1,565.6 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 shows the settlement price the previous day (i.e., July 12, 2012). The fifth number shows the most recent trading price, and the sixth number shows the price change from the previous day's settlement price. In the case of the August 2012 gold contract, the previous day's settlement price was \$1,565.3. The most recent trade was at \$1,589.7, \$24.4 higher than the previous day's settlement price. If \$1,589.7 proved to be the settlement price on July 13, 2012, the margin account of a trader with a long position in one contract would gain \$2,440 on July 13 and the margin account of a trader with a short position would lose this amount on July 13.

Trading Volume and Open Interest

The final column of Table 2.2 shows the *trading volume*. The trading volume is the number of contracts traded in a day. It can be contrasted with the *open interest*, which is the number of contracts outstanding, that is, the number of long positions or, equivalently, the number of short positions.

If there is a large amount of trading by day traders (i.e., traders who enter into a position and close it out on the same day) the volume of trading in a day can be greater than either the beginning-of-day or end-of-day open interest.

Patterns of Futures

Futures prices can show a number of different patterns. In Table 2.2, gold futures prices and live cattle futures prices are an increasing function of maturity. This is known as a

normal market. Soybean futures prices are a decreasing function of maturity. This is known as an *inverted market*. Other commodities such as crude oil, corn, and wheat showed patterns that were partly normal and partly inverted on July 13, 2012.

2.7 DELIVERY

As mentioned earlier in this chapter, very few of the futures contracts that are entered into lead to delivery of the underlying asset. Most are closed out early. Nevertheless, it is the possibility of eventual delivery that determines the futures price. An understanding of delivery procedures is therefore important.

The period during which delivery can be made is defined by the exchange and varies from contract to contract. The decision on when to deliver is made by the party with the short position, whom we shall refer to as investor A. When investor A decides to deliver, investor A's broker issues a notice of intention to deliver to the exchange clearing house. This notice states how many contracts will be delivered and, in the case of commodities, also specifies where delivery will be made and what grade will be delivered. The exchange then chooses a party with a long position to accept delivery.

Suppose that investor B was the party on the other side of investor A's futures contract when it was entered into. It is important to realize that there is no reason to expect that it will be investor B who takes delivery. Investor B may well have closed out his or her position by trading with investor C, investor C may have closed out his or her position by trading with investor D, and so on. The usual rule chosen by the exchange is to pass the notice of intention to deliver on to the party with the oldest outstanding long position. Parties with long positions must accept delivery notices. However, if the notices are transferable, long investors have a short period of time, usually half an hour, to find another party with a long position that is prepared to accept the notice from them.

In the case of a commodity, taking delivery usually means accepting a warehouse receipt in return for immediate payment. The party taking delivery is then responsible for all warehousing costs. In the case of livestock futures, there may be costs associated with feeding and looking after the animals (see Business Snapshot 2.1). In the case of financial futures, delivery is usually made by wire transfer. For all contracts, the price paid is usually the most recent settlement price. If specified by the exchange, this price is adjusted for grade, location of delivery, and so on. The whole delivery procedure from the issuance of the notice of intention to deliver to the delivery itself generally takes two to three days.

There are three critical days for a contract. These are the first notice day, the last notice day, and the last trading day. The *first notice day* is the first day on which a notice of intention to make delivery can be submitted to the exchange. The *last notice day* is the last such day. The *last trading day* is generally a few days before the last notice day. To avoid the risk of having to take delivery, an investor with a long position should close out his or her contracts prior to the first notice day.

Cash Settlement

Some financial futures, such as those on stock indices discussed in Chapter 3, are settled in cash because it is inconvenient or impossible to deliver the underlying asset. In the

case of the futures contract on the S&P 500, for example, delivering the underlying asset would involve delivering a portfolio of 500 stocks. When a contract is settled in cash, all outstanding contracts are declared closed on a predetermined day. The final settlement price is set equal to the spot price of the underlying asset at either the open or close of trading on that day. For example, in the S&P 500 futures contract traded by the CME Group, the predetermined day is the third Friday of the delivery month and final settlement is at the opening price.

2.8 TYPES OF TRADER AND TYPES OF ORDER

There are two main types of trader executing trades: *futures commission merchants* (FCMs) and *locals*. FCMs are following the instructions of their clients and charge a commission for doing so; locals are trading on their own account.

Individuals taking positions, whether locals or the clients of FCMs, can be categorized as hedgers, speculators, or arbitrageurs, as discussed in Chapter 1. Speculators can be classified as scalpers, day traders, or position traders. *Scalpers* are watching for very short term trends and attempt to profit from small changes in the contract price. They usually hold their positions for only a few minutes. *Day traders* hold their positions for less than one trading day. They are unwilling to take the risk that adverse news will occur overnight. *Position traders* hold their positions for much longer periods of time. They hope to make significant profits from major movements in the markets.

Orders

The simplest type of order placed with a broker is a *market order*. It is a request that a trade be carried out immediately at the best price available in the market. However, there are many other types of orders. We will consider those that are more commonly used.

A *limit order* specifies a particular price. The order can be executed only at this price or at one more favorable to the investor. Thus, if the limit price is $30 for an investor wanting to buy, the order will be executed only at a price of $30 or less. There is, of course, no guarantee that the order will be executed at all, because the limit price may never be reached.

A *stop order* or *stop-loss order* also specifies a particular price. The order is executed at the best available price once a bid or offer is made at that particular price or a less-favorable price. Suppose a stop order to sell at $30 is issued when the market price is $35. It becomes an order to sell when and if the price falls to $30. In effect, a stop order becomes a market order as soon as the specified price has been hit. The purpose of a stop order is usually to close out a position if unfavorable price movements take place. It limits the loss that can be incurred.

A *stop–limit order* is a combination of a stop order and a limit order. The order becomes a limit order as soon as a bid or offer is made at a price equal to or less favorable than the stop price. Two prices must be specified in a stop–limit order: the stop price and the limit price. Suppose that, at the time the market price is $35, a stop–limit order to buy is issued with a stop price of $40 and a limit price of $41. As soon as there is a bid or offer at $40, the stop–limit becomes a limit order at $41. If the stop price and the limit price are the same, the order is sometimes called a *stop-and-limit order*.

A *market-if-touched order* (MIT) is executed at the best available price after a trade occurs at a specified price or at a price more favorable than the specified price. In effect, an MIT becomes a market order once the specified price has been hit. An MIT is also known as a *board order*. Consider an investor who has a long position in a futures contract and is issuing instructions that would lead to closing out the contract. A stop order is designed to place a limit on the loss that can occur in the event of unfavorable price movements. By contrast, a market-if-touched order is designed to ensure that profits are taken if sufficiently favorable price movements occur.

A *discretionary order* or *market-not-held order* is traded as a market order except that execution may be delayed at the broker's discretion in an attempt to get a better price.

Some orders specify time conditions. Unless otherwise stated, an order is a day order and expires at the end of the trading day. A *time-of-day order* specifies a particular period of time during the day when the order can be executed. An *open order* or a *good-till-canceled order* is in effect until executed or until the end of trading in the particular contract. A *fill-or-kill order*, as its name implies, must be executed immediately on receipt or not at all.

2.9 REGULATION

Futures markets in the United States are currently regulated federally by the Commodity Futures Trading Commission (CFTC; www.cftc.gov), which was established in 1974.

The CFTC looks after the public interest. It is responsible for ensuring that prices are communicated to the public and that futures traders report their outstanding positions if they are above certain levels. The CFTC also licenses all individuals who offer their services to the public in futures trading. The backgrounds of these individuals are investigated, and there are minimum capital requirements. The CFTC deals with complaints brought by the public and ensures that disciplinary action is taken against individuals when appropriate. It has the authority to force exchanges to take disciplinary action against members who are in violation of exchange rules.

With the formation of the National Futures Association (NFA; www.nfa.futures.org) in 1982, some of responsibilities of the CFTC were shifted to the futures industry itself. The NFA is an organization of individuals who participate in the futures industry. Its objective is to prevent fraud and to ensure that the market operates in the best interests of the general public. It is authorized to monitor trading and take disciplinary action when appropriate. The agency has set up an efficient system for arbitrating disputes between individuals and its members.

From time to time other bodies such as the Securities and Exchange Commission (SEC; www.sec.gov), the Federal Reserve Board (www.federalreserve.gov), and the U.S. Treasury Department (www.treas.gov) have claimed jurisdictional rights over some aspects of futures trading. These bodies are concerned with the effects of futures trading on the spot markets for securities such as stocks, Treasury bills, and Treasury bonds.

Trading Irregularities

Most of the time futures markets operate efficiently and in the public interest. However, from time to time trading irregularities do come to light. One type of trading irregularity

occurs when an investor group tries to "corner the market."[4] The investor group takes a huge long futures position and also tries to exercise some control over the supply of the underlying commodity. As the maturity of the futures contracts is approached, the investor group does not close out its position, so that the number of outstanding futures contracts may exceed the amount of the commodity available for delivery. The holders of short positions realize that they will find it difficult to deliver and become desperate to close out their positions. The result is a large rise in both futures and spot prices. Regulators usually deal with this type of abuse of the market by increasing margin requirements or imposing stricter position limits or prohibiting trades that increase a speculator's open position or requiring market participants to close out their positions.

Other types of trading irregularities can involve the traders on the floor of the exchange. These received some publicity early in 1989 when it was announced that the FBI had carried out a two-year investigation, using undercover agents, of trading on the Chicago Board of Trade and the Chicago Mercantile Exchange. The investigation was initiated because of complaints filed by a large agricultural concern. The alleged offenses included overcharging customers, not paying customers the full proceeds of sales, and traders using their knowledge of customer orders to trade first for themselves. (The latter is known as *front running*.)

2.10 ACCOUNTING AND TAX

The full details of the accounting and tax treatment of futures contracts are beyond the scope of this book. A trader who wants detailed information on this should obtain professional advice. This section provides some general background information.

Accounting

Accounting standards require changes in the market value of a futures contract to be recognized when they occur unless the contract qualifies as a hedge. If the contract does qualify as a hedge, then gains or losses are generally recognized for accounting purposes in the same period in which the gains or losses from the item being hedged are recognized. The latter treatment is referred to as *hedge accounting*.

Example 2.1 considers a company with a December year end. In September 2013 it buys a March 2014 corn futures contract and closes out the position at the end of February 2014. Suppose that the futures prices are 750 cents per bushel when the contract is entered into, 770 cents per bushel at the end of 2013, and 780 cents per bushel when the contract is closed out. The contract is for the delivery of 5,000 bushels. If the contract does not qualify as a hedge, the gains for accounting purposes are

$$5{,}000 \times (7.70 - 7.50) = \$1{,}000$$

in 2013 and

$$5{,}000 \times (7.80 - 7.70) = \$500$$

in 2014. If the company is hedging the purchase of 5,000 bushels of corn in February

[4] Possibly the best known example of this involves the activities of the Hunt brothers in the silver market in 1979–80. Between the middle of 1979 and the beginning of 1980, their activities led to a price rise from $6 per ounce to $50 per ounce.

Example 2.1 Accounting treatment of a futures transaction

A company buys 5,000 bushels of March 2014 corn in September 2013 for 750 cents per bushel and closes out the position in February 2014 for 780 cents per bushel. The price of March 2014 corn on December 31, 2013, the company's year end, is 770 cents per bushel.

If contract is not a hedge, the treatment of these transactions leads to:
Accounting profit in 2013 = 5,000 × 20 cents = \$1,000.
Accounting profit in 2014 = 5,000 × 10 cents = \$500.

If contract is hedging a purchase of corn in 2014, the result is:
Accounting profit in 2013 = \$0.
Accounting profit in 2014 = 5,000 × 30 cents = \$1,500.

2014 so that the contract qualifies for hedge accounting, the entire gain of \$1,500 is realized in 2014 for accounting purposes.

The treatment of hedging gains and losses is sensible. If the company is hedging the purchase of 5,000 bushels of corn in February 2014, the effect of the futures contract is to ensure that the price paid is close to 750 cents per bushel. The accounting treatment reflects that this price is paid in 2014.

In June 1998, the Financial Accounting Standards Board issued Statement No. 133 (FAS 133), Accounting for Derivative Instruments and Hedging Activities. FAS 133 applies to all types of derivatives (including futures, forwards, swaps, and options). It requires all derivatives to be included on the balance sheet at fair market value.[5] It increases disclosure requirements. It also gives companies far less latitude than previously in using hedge accounting. For hedge accounting to be used, the hedging instrument must be highly effective in offsetting exposures and an assessment of this effectiveness is required every three months. A similar standard IAS 39 has been issued by the International Accounting Standards Board.

Tax

Under the U.S. tax rules, two key issues are the nature of a taxable gain or loss and the timing of the recognition of the gain or loss. Gains or losses are either classified as capital gains/losses or as part of ordinary income.

For a corporate taxpayer, capital gains are taxed at the same rate as ordinary income, and the ability to deduct losses is restricted. Capital losses are deductible only to the extent of capital gains. A corporation may carry back a capital loss for three years and carry it forward for up to five years. For a noncorporate taxpayer, short-term capital gains are taxed at the same rate as ordinary income, but long-term capital gains are taxed at a lower rate than ordinary income. (Long-term capital gains are gains from the sale of a capital asset held for longer than one year; short term capital gains are the gains from the sale of a capital asset held one year or less.) The Taxpayer Relief Act of 1997 widened the rate differential between ordinary income and long-term capital gains. For a noncorporate taxpayer, capital losses are deductible to the extent of capital gains plus ordinary income up to \$3,000 and can be carried forward indefinitely.

[5] Previously the attraction of derivatives in some situations was that they were "off-balance-sheet" items.

Generally, positions in futures contracts are treated as if they are closed out on the last day of the tax year. For the noncorporate taxpayer this gives rise to capital gains and losses. These are treated as if they are 60% long term and 40% short term without regard to the holding period. This is referred to as the "60/40" rule. A noncorporate taxpayer may elect to carry back for three years any net losses from the 60/40 rule to offset any gains recognized under the rule in the previous three years.

Hedging transactions are exempt from this rule. The definition of a hedge transaction for tax purposes is different from that for accounting purposes. The tax regulations define a hedging transaction as a transaction entered into in the normal course of business primarily for one of the following reasons:

1. To reduce the risk of price changes or currency fluctuations with respect to property that is held or to be held by the taxpayer for the purposes of producing ordinary income
2. To reduce the risk of price or interest rate changes or currency fluctuations with respect to borrowings made by the taxpayer.

A hedging transaction must be clearly identified in a timely manner in the company's records as a hedge. Gains or losses from hedging transactions are treated as ordinary income. The timing of the recognition of gains or losses from hedging transactions generally matches the timing of the recognition of income or expense associated with the transaction being hedged.

2.11 FORWARD vs. FUTURES CONTRACTS

As explained in Chapter 1, forward contracts are similar to futures contracts in that they are agreements to buy or sell an asset at a certain time in the future for a certain price. Whereas futures contracts are traded on an exchange, forward contracts are traded in the over-the-counter market. They are typically entered into by two financial institutions or by a financial institution and one of its clients.

One of the parties to a forward contract assumes a *long position* and agrees to buy the asset on a certain specified date for a certain price. The other party assumes a *short position* and agrees to sell the asset on the same date for the same price. Forward contracts do not have to conform to the standards of a particular exchange. The contract delivery date can be any date mutually convenient to the two parties. Usually, in forward contracts a single delivery date is specified, whereas in futures contracts there is a range of possible delivery dates.

Unlike futures contracts, forward contracts are not settled daily. The two parties contract to settle up on the specified delivery date. Whereas most futures contracts are closed out prior to delivery, most forward contracts do lead to delivery of the physical asset or to final settlement in cash. Table 2.3 summarizes the main differences between forward and futures contracts.

Profits from Forward and Futures Contracts

Suppose that the sterling exchange rate for a 90-day forward contract is 1.6000 dollars per pound and that this rate is also the futures price for a contract that will be delivered in exactly 90 days. Under the forward contract, the whole gain or loss is realized at the

Table 2.3 Comparison of forward and futures contracts

Forward	*Futures*
Private contract between two parties	Traded on an exchange
Not standardized	Standardized contract
Usually one specified delivery date	Range of delivery dates
Settled at end of contract	Settled daily
Delivery or final cash settlement usually takes place	Contract is usually closed out prior to maturity
Some credit risk	Virtually no credit risk

end of the life of the contract. Under the futures contract, the gain or loss is realized day by day because of the daily settlement procedures. Figure 2.3 shows the net profit as a function of the exchange rate for 90-day long and short forward or futures positions on £1 million.

Example 2.2 considers the situation where investor A is long £1 million in a 90-day forward contract, and investor B is long £1 million in 90-day futures contracts. (Each futures contract is for the purchase or sale of £62,500, so investor B has purchased a total of 16 contracts.) Assume that the spot exchange rate in 90 days proves to be 1.7000 dollars per pound. Investor A makes a gain of $100,000 on the 90th day. Investor B makes the same gain—but spread out over the 90-day period. On some days investor B may realize a loss, whereas on other days he or she makes a gain. However, in total, when losses are netted against gains, there is a gain of $100,000 over the 90-day period.

Foreign Exchange Quotes

Both forward and futures contracts trade actively on foreign currencies. However, there is sometimes a difference in the way exchange rates are quoted in the two markets. Futures prices are always quoted as the number of U.S. dollars per unit of the foreign

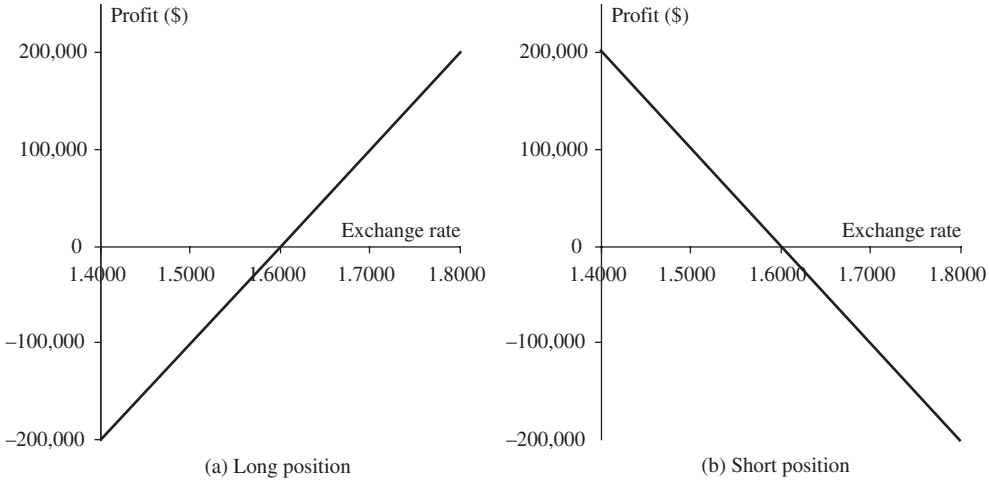

Figure 2.3 Profit from (a) long and (b) short forward or futures position on £1 million

Example 2.2 Futures vs. forwards

Investor A takes a long position in a 90-day forward contract on £1 million. The forward price is 1.6000 dollars per pound. Investor B takes a long position in 90-day futures contracts on £1 million. The futures price is also 1.6000 dollars per pound. At the end of the 90 days, the exchange rate proves to be 1.7000.

The result of this is that investors A and B each make a total gain equal to

$$(1.7000 - 1.6000) \times 1{,}000{,}000 = \$100{,}000$$

Investor A's gain is made entirely on the 90th day. Investor B's gain is realized day by day over the 90-day period. On some days investor B may realize a loss, whereas on other days he or she will realize a gain.

currency or as the number of U.S. cents per unit of the foreign currency. Forward prices are always quoted in the same way as spot prices. This means that for the British pound, the euro, the Australian dollar, and the New Zealand dollar, the forward quotes show the number of U.S. dollars per unit of the foreign currency and are directly comparable with futures quotes. For other major currencies, forward quotes show the number of units of the foreign currency per U.S. dollar (USD). Consider the Canadian dollar (CAD). A futures price quote of 0.9500 USD per CAD corresponds to a forward price quote of 1.0526 CAD per USD (1.0526 = 1/0.9500).

SUMMARY

A very high proportion of the futures contracts that are traded do not lead to the delivery of the underlying asset. This is because traders usually enter into offsetting contracts to close out their positions before the delivery period is reached. However, it is the possibility of final delivery that drives the determination of the futures price. For each futures contract, there is a range of days during which delivery can be made and a well-defined delivery procedure. Some contracts, such as those on stock indices, are settled in cash rather than by delivery of the underlying asset.

The specification of contracts is an important activity for a futures exchange. The two sides to any contract must know what can be delivered, where delivery can take place, and when delivery can take place. They also need to know details on the trading hours, how prices will be quoted, maximum daily price movements, and so on. New contracts must be approved by the Commodity Futures Trading Commission before trading starts.

Margin requirements are an important aspect of futures markets. An investor keeps a margin account with his or her broker. The account is adjusted daily to reflect gains or losses, and from time to time the broker may require the account to be topped up if adverse price movements have taken place. The broker either must be a clearing house member or must maintain a margin account with a clearing house member. Each clearing house member maintains a margin account with the exchange clearing house. The balance in the account is adjusted daily to reflect gains and losses on the business for which the clearing house member is responsible.

In over-the-counter derivatives markets, transactions are cleared either bilaterally or centrally. When bilateral clearing is used, collateral frequently has to be posted by one or both parties to reduce credit risk. When central clearing is used, a central clearing party (CCP) stands between the two sides and performs much the same function as an exchange clearing house.

Forward contracts differ from futures contracts in a number of ways. Forward contracts are private arrangements between two parties, whereas futures contracts are traded on exchanges. There is generally a single delivery date in a forward contract, whereas futures contracts frequently involve a range of such dates. Because they are not traded on exchanges, forward contracts do not need to be standardized. A forward contract is not usually settled until the end of its life, and most contracts do in fact lead to delivery of the underlying asset or a cash settlement at this time.

In the next few chapters we will examine in more detail the ways in which forward and futures contracts can be used for hedging. We will also look at how forward and futures prices are determined.

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Quiz (Answers at End of Book)

2.1. Distinguish between the terms *open interest* and *trading volume*.

2.2. What is the difference between a *local* and a *futures commission merchant*?

2.3. Suppose that you enter into a short futures contract to sell July silver for \$27.20 per ounce. The size of the contract is 5,000 ounces. The initial margin is \$4,000, and the maintenance margin is \$3,000. What change in the futures price will lead to a margin call? What happens if you do not meet the margin call?

2.4. Suppose that in September 2013 a company takes a long position in a contract on May 2014 crude oil futures. It closes out its position in March 2014. The futures price (per barrel) is \$88.30 when it enters into the contract, \$90.50 when it closes out the position, and \$89.10 at the end of December 2013. One contract is for the delivery of

1,000 barrels. What is the company's profit? When is it realized? How is it taxed if it is (a) a hedger and (b) a speculator? Assume that the company has a December 31 year end.

2.5. What does a stop order to sell at $2 mean? When might it be used? What does a limit order to sell at $2 mean? When might it be used?

2.6. What is the difference between the operation of the margin accounts administered by a clearing house and those administered by a broker?

2.7. What differences exist in the way prices are quoted in the foreign exchange futures market, the foreign exchange spot market, and the foreign exchange forward market?

Practice Questions (Answers in Solutions Manual/Study Guide)

2.8. The party with a short position in a futures contract sometimes has options as to the precise asset that will be delivered, where delivery will take place, when delivery will take place, and so on. Do these options increase or decrease the futures price? Explain your reasoning.

2.9. What are the most important aspects of the design of a new futures contract?

2.10. Explain how margin accounts protect investors against the possibility of default.

2.11. A trader buys two July futures contracts on orange juice. Each contract is for the delivery of 15,000 pounds. The current futures price is 160 cents per pound, the initial margin is $6,000 per contract, and the maintenance margin is $4,500 per contract. What price change would lead to a margin call? Under what circumstances could $2,000 be withdrawn from the margin account?

2.12. Show that, if the futures price of a commodity is greater than the spot price during the delivery period, then there is an arbitrage opportunity. Does an arbitrage opportunity exist if the futures price is less than the spot price? Explain your answer.

2.13. Explain the difference between a market-if-touched order and a stop order.

2.14. Explain what a stop-limit order to sell at 20.30 with a limit of 20.10 means.

2.15. At the end of one day a clearing house member is long 100 contracts, and the settlement price is $50,000 per contract. The original margin is $2,000 per contract. On the following day the member becomes responsible for clearing an additional 20 long contracts, entered into at a price of $51,000 per contract. The settlement price at the end of this day is $50,200. How much does the member have to add to its margin account with the exchange clearing house?

2.16. On July 1, 2013, a Japanese company enters into a forward contract to buy $1 million with yen on January 1, 2014. On September 1, 2013, it enters into a forward contract to sell $1 million on January 1, 2014. Describe the profit or loss the company will make in dollars as a function of the forward exchange rates on July 1, 2013, and September 1, 2013.

2.17. The forward price of the Swiss franc for delivery in 45 days is quoted as 1.1000. The futures price for a contract that will be delivered in 45 days is 0.9000. Explain these two quotes. Which is more favorable for an investor wanting to sell Swiss francs?

2.18. Suppose you call your broker and issue instructions to sell one July hogs contract. Describe what happens.

2.19. "Speculation in futures markets is pure gambling. It is not in the public interest to allow speculators to trade on a futures exchange." Discuss this viewpoint.

2.20. Explain the difference between bilateral and central clearing for OTC derivatives.

2.21. What do you think would happen if an exchange started trading a contract in which the quality of the underlying asset was incompletely specified?

2.22. "When a futures contract is traded on the floor of the exchange, it may be the case that the open interest increases by one, stays the same, or decreases by one." Explain this statement.

2.23. Suppose that on October 24, 2013, a company sells one April 2014 live-cattle futures contract. It closes out its position on January 21, 2014. The futures price (per pound) is 91.20 cents when it enters into the contract, 88.30 cents when it closes out the position, and 88.80 cents at the end of December 2013. One contract is for the delivery of 40,000 pounds of cattle. What is the profit? How is it taxed if the company is (a) a hedger and (b) a speculator? Assume that the company has a December 31 year end.

2.24. Explain how CCPs work. What are the advantages to the financial system of requiring all standardized derivatives transactions to be cleared through CCPs?

Further Questions

2.25. Trader A enters into futures contracts to buy 1 million euros for 1.4 million dollars in three months. Trader B enters in a forward contract to do the same thing. The exchange rate (dollars per euro) declines sharply during the first two months and then increases for the third month to close at 1.4300. Ignoring daily settlement, what is the total profit of each trader? When the impact of daily settlement is taken into account, which trader has done better?

2.26. Explain what is meant by open interest. Why does the open interest usually decline during the month preceding the delivery month? On a particular day, there were 2,000 trades in a particular futures contract. This means that there were 2,000 buyers (going long) and 2,000 sellers (going short). Of the 2,000 buyers, 1,400 were closing out positions and 600 were entering into new positions. Of the 2,000 sellers, 1,200 were closing out positions and 800 were entering into new positions. What is the impact of the day's trading on open interest?

2.27. One orange juice futures contract is on 15,000 pounds of frozen concentrate. Suppose that in September 2013 a company sells a March 2015 orange juice futures contract for 120 cents per pound. In December 2013, the futures price is 140 cents; in December 2014, it is 110 cents; and in February 2015, it is closed out at 125 cents. The company has a December year end. What is the company's profit or loss on the contract? How is it realized? What is the accounting and tax treatment of the transaction if the company is classified as (a) a hedger and (b) a speculator?

2.28. A company enters into a short futures contract to sell 5,000 bushels of wheat for 450 cents per bushel. The initial margin is $3,000 and the maintenance margin is $2,000. What price change would lead to a margin call? Under what circumstances could $1,500 be withdrawn from the margin account?

2.29. Suppose that there are no storage costs for crude oil and the interest rate for borrowing or lending is 5% per annum. How could you make money if the June and December futures contracts for a particular year trade at $80 and $86, respectively.

2.30. What position is equivalent to a long forward contract to buy an asset at K on a certain date and a put option to sell it for K on that date.

2.31. A company has derivatives transactions with Banks A, B, and C that are worth +$20 million, −$15 million, and −$25 million, respectively, to the company. How much margin or collateral does the company have to provide in each of the following two situations?
(a) The transactions are cleared bilaterally and are subject to one-way collateral agreements where the company posts variation margin but no initial margin. The banks do not have to post collateral.
(b) The transactions are cleared centrally through the same CCP and the CCP requires a total initial margin of $10 million.

2.32. A bank's derivatives transactions with a counterparty are worth +$10 million to the bank and are cleared bilaterally. The counterparty has posted $10 million of cash collateral. What credit exposure does the bank have?

2.33. The author's website (www.rotman.utoronto.ca/~hull/data) contains daily closing prices for the crude oil futures contract and the gold futures contract. Download the data and answer the following:
(a) How high do the maintenance margin levels for oil and gold have to be set so that there is a 1% chance that an investor with a balance slightly above the maintenence margin level on a particular day has a negative balance two days later. How high do they have to be for a 0.1% chance? Assume daily price changes are normally distributed with mean zero. Explain why the exchange might be interested in this calculation.
(b) Imagine an investor who starts with a long position in the oil contract at the beginning of the period covered by the data and keeps the contract for the whole of the period of time covered by the data. Margin balances in excess of the initial margin are withdrawn. Use the maintenance margin you calculated in part (a) for a 1% risk level and assume that the maintenance margin is 75% of the initial margin. Calculate the number of margin calls and the number of times the investor has a negative margin balance. Assume that all margin calls are met in your calculations. Repeat the calculations for an investor who starts with a short position in the gold contract.

CHAPTER 3

Hedging Strategies Using Futures

Many of the participants in futures markets are hedgers. Their aim is to use futures markets to reduce a particular risk they face. This risk might relate to fluctuations in the price of oil, a foreign exchange rate, the level of the stock market, or some other variable. A *perfect hedge* is one that completely eliminates the risk. Perfect hedges are rare. For the most part, therefore, a study of hedging using futures contracts is a study of the ways in which hedges can be constructed so that they perform as close to perfect as possible.

In this chapter we consider a number of general issues associated with the way hedges are set up. When is a short futures position appropriate? When is a long futures position appropriate? Which futures contract should be used? What is the optimal size of the futures position for reducing risk? At this stage, we restrict our attention to what might be termed *hedge-and-forget* strategies. We assume that no attempt is made to adjust the hedge once it has been put in place. The hedger simply takes a futures position at the beginning of the life of the hedge and closes out the position at the end of the life of the hedge. In Chapter 17, we will examine dynamic hedging strategies in which the hedge is monitored closely and frequent adjustments are made.

The chapter initially treats futures contracts as forward contracts (i.e., it ignores daily settlement). Later it explains an adjustment known as "tailing" that takes account of the difference between futures and forwards.

3.1 BASIC PRINCIPLES

When an individual or company chooses to use futures markets to hedge a risk, the objective is usually to take a position that neutralizes the risk as far as possible. Consider a company that knows it will gain $10,000 for each 1 cent increase in the price of a commodity over the next three months and lose $10,000 for each 1 cent decrease in the price during the same period. To hedge, the company's treasurer should take a short futures position that is designed to offset this risk. The futures position should lead to a loss of $10,000 for each 1 cent increase in the price of the commodity over the three months and a gain of $10,000 for each 1 cent decrease in the price during this period. If the price of the commodity goes down, the gain on the futures position offsets the loss

on the rest of the company's business. If the price of the commodity goes up, the loss on the futures position is offset by the gain on the rest of the company's business.

Short Hedges

A *short hedge* is a hedge, such as the one just described, that involves a short position in futures contracts. A short hedge is appropriate when the hedger already owns an asset and expects to sell it at some time in the future. For example, a short hedge could be used by a farmer who owns some hogs and knows that they will be ready for sale at the local market in two months. A short hedge can also be used when an asset is not owned right now but will be owned at some time in the future. Consider, for example, a U.S. exporter who knows that he or she will receive euros in three months. The exporter will realize a gain if the euro increases in value relative to the U.S. dollar and will sustain a loss if the euro decreases in value relative to the U.S. dollar. A short futures position leads to a loss if the euro increases in value and a gain if it decreases in value. It has the effect of offsetting the exporter's risk.

We will use Example 3.1 to provide a more detailed illustration of the operation of a short hedge. It is May 15 today and an oil producer has just negotiated a contract to sell 1 million barrels of crude oil. It has been agreed that the price that will apply in the contract is the market price on August 15. The oil producer is therefore in the position where it will gain \$10,000 for each 1 cent increase in the price of oil over the next three months and lose \$10,000 for each 1 cent decrease in the price during this period. The spot price on May 15 is \$80 per barrel and the crude oil futures price for August delivery for the CME Group contract is \$79 per barrel. Because each futures contract traded by the CME Group is for the delivery of 1,000 barrels, the company can hedge its exposure by shorting 1,000 futures contracts. If the oil producer closes out its position on August 15, the effect of the strategy should be to lock in a price close to \$79 per barrel.

To illustrate what might happen, suppose that the spot price on August 15 proves to be \$75 per barrel. The company realizes \$75 million for the oil under its sales contract. Because August is the delivery month for the futures contract, the futures price on August 15 should be very close to the spot price of \$75 on that date. The company therefore gains approximately

$$\$79 - \$75 = \$4$$

Example 3.1 A short hedge

It is May 15. An oil producer has negotiated a contract to sell 1 million barrels of crude oil. The price in the sales contract is the spot price on August 15. Quotes:

Spot price of crude oil: \$80 per barrel
August oil futures price: \$79 per barrel

The oil producer can hedge with the following transactions:

May 15: Short 1,000 August futures contracts on crude oil
August 15: Close out futures position

After gains or losses on the futures are taken into account, the price received by the company is close to \$79 per barrel.

per barrel, or \$4 million in total from the short futures position. The total amount realized from both the futures position and the sales contract is therefore approximately \$79 per barrel, or \$79 million in total.

For an alternative outcome, suppose that the price of oil on August 15 proves to be \$85 per barrel. The company realizes \$85 for the oil and loses approximately

$$\$85 - \$79 = \$6$$

per barrel on the short futures position. Again, the total amount realized is approximately \$79 million. It is easy to see that in all cases the company ends up with approximately \$79 million.

Long Hedges

Hedges that involve taking a long position in a futures contract are known as *long hedges*. A long hedge is appropriate when a company knows it will have to purchase a certain asset in the future and wants to lock in a price now.

This is illustrated in Example 3.2, where a copper fabricator knows it will need 100,000 pounds of copper on May 15. The futures price for May delivery is 320 cents per pound. The fabricator can hedge its position by taking a long position in four futures contracts traded by the CME Group and closing its position on May 15. Each contract is for the delivery of 25,000 pounds of copper. The strategy has the effect of locking in the price of the required quantity of copper at close to 320 cents per pound.

Suppose that the spot price of copper on May 15 proves to be 325 cents per pound. Because May is the delivery month for the futures contract, this should be very close to the futures price. The fabricator therefore gains approximately

$$100{,}000 \times (\$3.25 - \$3.20) = \$5{,}000$$

on the futures contracts. It pays $100{,}000 \times \$3.25 = \$325{,}000$ for the copper, making the net cost approximately $\$325{,}000 - \$5{,}000 = \$320{,}000$. For an alternative outcome, suppose that the spot price is 305 cents per pound on May 15. The fabricator then loses approximately

$$100{,}000 \times (\$3.20 - \$3.05) = \$15{,}000$$

on the futures contract and pays $100{,}000 \times \$3.05 = \$305{,}000$ for the copper. Again, the net cost is approximately \$320,000, or 320 cents per pound.

Example 3.2 A long hedge

It is January 15. A copper fabricator knows it will require 100,000 pounds of copper on May 15 to meet a certain contract. The spot price of copper is 340 cents per pound and the May futures price is 320 cents per pound.

The copper fabricator can hedge with the following transactions:

January 15: Take a long position in four May futures contracts on copper
May 15: Close out the position

After gains or losses on the futures are taken into account, the price paid by the company is close to 320 cents per pound.

Note that in this case it is better for the company to use futures contracts than to buy the copper on January 15 in the spot market. If it does the latter, it will pay 340 cents per pound instead of 320 cents per pound and will incur both interest costs and storage costs. For a company using copper on a regular basis, this disadvantage would be offset by the convenience of having the copper on hand.[1] However, for a company that knows it will not require the copper until May 15, the futures contract alternative is likely to be preferred.

In Examples 3.1 and 3.2, we assume that the futures position is closed out in the delivery month. The hedge has the same basic effect if delivery is allowed to happen. However, making or taking delivery can be costly and inconvenient. For this reason, delivery is not usually made even when the hedger keeps the futures contract until the delivery month. As will be discussed later, hedgers with long positions usually avoid any possibility of having to take delivery by closing out their positions before the delivery period.

We have also assumed in the two examples that a futures contract is the same as a forward contract. In practice, daily settlement does have a small effect on the performance of a hedge. As explained in Chapter 2, it means that the payoff from the futures contract is realized day by day throughout the life of the hedge rather than all at the end.

3.2 ARGUMENTS FOR AND AGAINST HEDGING

The arguments in favor of hedging are so obvious that they hardly need to be stated. Most companies are in the business of manufacturing, or retailing or wholesaling, or providing a service. They have no particular skills or expertise in predicting variables such as interest rates, exchange rates, and commodity prices. It makes sense for them to hedge the risks associated with these variables as they become aware of them. The companies can then focus on their main activities—for which presumably they do have particular skills and expertise. By hedging, they avoid unpleasant surprises, such as sharp rises in the price of a commodity that is being purchased.

In practice, many risks are left unhedged. In the rest of this section, we will explore some of the reasons for this.

Hedging and Shareholders

One argument sometimes put forward is that the shareholders can, if they wish, do the hedging themselves. They do not need the company to do it for them. This argument is, however, open to question. It assumes that shareholders have as much information as the company's management about the risks faced by the company. In most instances, this is not the case. The argument also ignores commissions and other transactions costs. These are less expensive per dollar of hedging for large transactions than for small transactions. Hedging is therefore likely to be less expensive when carried out by the company than when it is carried out by individual shareholders. Indeed, the size of futures contracts makes hedging by individual shareholders impossible in many situations.

[1] See Chapter 5 for a discussion of convenience yields.

One thing that shareholders can do far more easily than a corporation is diversify risk. A shareholder with a well-diversified portfolio may be immune to many of the risks faced by a corporation. For example, in addition to holding shares in a company that uses copper, a well-diversified shareholder may hold shares in a copper producer, so that there is very little overall exposure to the price of copper. If companies are acting in the best interests of well-diversified shareholders, it can be argued that hedging is unnecessary in many situations. However, the extent to which managers are in practice influenced by this type of argument is open to question.

Hedging and Competitors

If hedging is not the norm in a certain industry, it may not make sense for one particular company to choose to be different from all others. Competitive pressures from within the industry may be such that the prices of the goods and services produced by the industry fluctuate to reflect raw material costs, interest rates, exchange rates, and so on. A company that does not hedge can expect its profit margin to be roughly constant. However, a company that does hedge can expect its profit margin to fluctuate!

To illustrate this point, consider two manufacturers of gold jewelry, SafeandSure Company and TakeaChance Company. We assume that most companies in the industry do not hedge against movements in the price of gold and that TakeaChance Company is no exception. However, SafeandSure Company has decided to be different from its competitors and to use futures contracts to hedge its purchase of gold over the next 18 months. If the price of gold goes up, economic pressures will tend to lead to a corresponding increase in the wholesale price of jewelry, so that TakeaChance Company's gross profit margin is unaffected. In contrast, SafeandSure Company's profit margin will increase after the effects of the hedge have been taken into account. If the price of gold goes down, economic pressures will tend to lead to a corresponding decrease in the wholesale price of jewelry. Again, TakeaChance Company's profit margin is unaffected. However, SafeandSure Company's profit margin goes down. In extreme conditions, SafeandSure Company's profit margin could become negative as a result of the "hedging" carried out! The situation is summarized in Table 3.1.

This example emphasizes the importance of looking at the big picture when hedging. All the implications of price changes on a company's profitability should be taken into account in the design of a hedging strategy to protect against the price changes.

Table 3.1 Danger in hedging when competitors do not hedge

Change in gold price	*Effect on Price of gold jewelry*	*Effect on Profits of TakeaChance Co.*	*Effect on Profits of SafeandSure Co.*
Increase	Increase	None	Increase
Decrease	Decrease	None	Decrease

Hedging Can Lead to a Worse Outcome

It is important to realize that a hedge using futures contracts can result in a decrease or an increase in a company's profits relative to its position with no hedging. In Example 3.1, if the price of oil goes down, the company loses money on its sale of 1 million barrels of oil, and the futures position leads to an offsetting gain. The treasurer can be congratulated for having had the foresight to put the hedge in place. Clearly, the company is better off than it would be with no hedging. Other executives in the organization, it is hoped, will appreciate the contribution made by the treasurer. If the price of oil goes up, the company gains from its sale of the oil, and the futures position leads to an offsetting loss. The company is in a worse position than it would have been in with no hedging. Although the hedging decision was perfectly logical, the treasurer may in practice have a difficult time justifying it. Suppose that the price of oil is \$89 on August 15 in Example 3.1, so that the company loses \$10 per barrel on the futures contract. We can imagine a conversation such as the following between the treasurer and the president:

President: This is terrible. We've lost \$10 million in the futures market in the space of three months. How could it happen? I want a full explanation.

Treasurer: The purpose of the futures contracts was to hedge our exposure to the price of oil—not to make a profit. Don't forget that we made about \$10 million from the favorable effect of the oil price increases on our business.

President: What's that got to do with it? That's like saying that we do not need to worry when our sales are down in California because they are up in New York.

Treasurer: If the price of oil had gone down . . .

President: I don't care what would have happened if the price of oil had gone down. The fact is that it went up. I really do not know what you were doing playing the futures markets like this. Our shareholders will expect us to have done particularly well this quarter. I'm going to have to explain to them that your actions reduced profits by \$10 million. I'm afraid this is going to mean no bonus for you this year.

Treasurer: That's unfair. I was only . . .

President: Unfair! You are lucky not to be fired. You lost \$10 million.

Treasurer: It all depends how you look at it . . .

It is easy to see why many treasurers are reluctant to hedge! Hedging reduces risk for the company. However, it may increase risks for the treasurer if others do not fully understand what is being done. The only real solution to this problem involves ensuring that all senior executives within the organization fully understand the nature of hedging before a hedging program is put in place. Ideally, hedging strategies are set by a company's board of directors and are clearly communicated to both the company's management and the shareholders. (See Business Snapshot 3.1 for a discussion of hedging by gold mining companies.)

Business Snapshot 3.1 Hedging by gold mining companies

It is natural for a gold mining company to consider hedging against changes in the price of gold. Typically it takes several years to extract all the gold from a mine. Once a gold mining company decides to go ahead with production at a particular mine, it has a big exposure to the price of gold. Indeed a mine that looks profitable at the outset could become unprofitable if the price of gold plunges.

Gold mining companies are careful to explain their hedging strategies to potential shareholders. Some gold mining companies do not hedge. They tend to attract shareholders who buy gold stocks because they want to benefit when the price of gold increases and are prepared to accept the risk of a loss from a decrease in the price of gold. Other companies choose to hedge. They estimate the number of ounces of gold they will produce each month for the next few years and enter into short futures or forward contracts to lock in the price for all or part of this.

Suppose you are Goldman Sachs and are approached by a gold mining company that wants to sell you a large amount of gold in one year at a fixed price. How do you set the price and then hedge your risk? The answer is that you can hedge by borrowing the gold from a central bank and immediately selling it in the spot market, investing the proceeds at the risk-free rate. At the end of the year, you buy the gold from the gold mining company and use it to repay the central bank. The fixed forward price you set for the gold reflects the risk-free rate you can earn and the lease rate you pay the central bank for borrowing the gold.

3.3 BASIS RISK

The hedges in the examples considered so far have been almost too good to be true. The hedger was able to identify the precise date in the future when an asset would be bought or sold. The hedger was then able to use futures contracts to remove almost all the risk arising from the price of the asset on that date. In practice, hedging is often not quite as straightforward. Some of the reasons are as follows:

1. The asset whose price is to be hedged may not be exactly the same as the asset underlying the futures contract.
2. The hedger may not be certain of the exact date the asset will be bought or sold.
3. The hedge may require the futures contract to be closed out before its delivery month.

These problems give rise to what is termed *basis risk*. This concept will now be explained.

The Basis

The *basis* in a hedging situation is as follows:[2]

$$\text{Basis} = \text{Spot price of asset to be hedged} - \text{Futures price of contract used}$$

[2] This is the usual definition. However, an alternative definition, Basis = Futures price − Spot price, is sometimes used, particularly when the futures contract is on a financial asset.

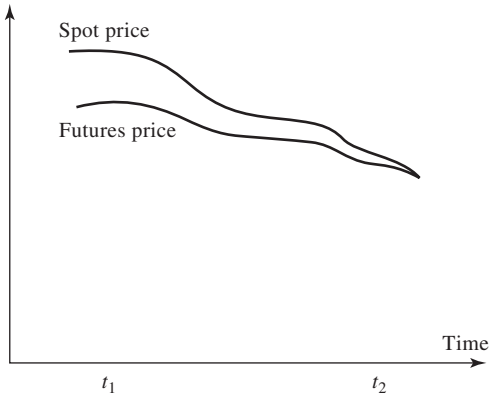

Figure 3.1 Variation of basis over time

If the asset to be hedged and the asset underlying the futures contract are the same, the basis should be zero at the expiration of the futures contract. Prior to expiration, the basis may be positive or negative.

As time passes, the spot price and a particular month's futures price do not necessarily change by the same amount and, as a result, the basis changes. An increase in the basis is referred to as a *strengthening of the basis* and a decrease in the basis is referred to as a *weakening of the basis*. Figure 3.1 illustrates how a basis might change over time in a situation where the basis is positive prior to expiration of the futures contract.

To examine the nature of basis risk, we will use the following notation:

S_1: Spot price at time t_1
S_2: Spot price at time t_2
F_1: Futures price at time t_1
F_2: Futures price at time t_2
b_1: Basis at time t_1
b_2: Basis at time t_2

We will assume that a hedge is put in place at time t_1 and closed out at time t_2. As an example, we will consider the case where the spot and futures prices at the time the hedge is initiated are \$2.50 and \$2.20, respectively, and that at the time the hedge is closed out they are \$2.00 and \$1.90, respectively. This means that $S_1 = 2.50$, $F_1 = 2.20$, $S_2 = 2.00$, and $F_2 = 1.90$. From the definition of the basis,

$$b_1 = S_1 - F_1 \quad \text{and} \quad b_2 = S_2 - F_2$$

so that, in our example, $b_1 = 0.30$ and $b_2 = 0.10$.

Consider first the situation of a hedger who knows that the asset will be sold at time t_2 and takes a short futures position at time t_1. The price realized for the asset is S_2 and the profit on the futures position is $F_1 - F_2$. The effective price obtained for the asset with hedging is therefore

$$S_2 + F_1 - F_2 = F_1 + b_2$$

In our example, this is \$2.30. The value of F_1 is known at time t_1. If b_2 were also known at this time, a perfect hedge would result. The hedging risk is the uncertainty associated

with b_2 and is known as *basis risk*. Consider next a situation where a company knows it will buy the asset at time t_2 and initiates a long hedge at time t_1. The price paid for the asset is S_2 and the loss on the hedge is $F_1 - F_2$. The effective price paid with hedging is therefore

$$S_2 + F_1 - F_2 = F_1 + b_2$$

This is the same expression as before and is \$2.30 in the example. The value of F_1 is known at time t_1, and the term b_2 represents basis risk.

Note that basis risk can lead to an improvement or a worsening of a hedger's position. Consider a company that uses a short hedge because it plans to sell the asset. If the basis strengthens (i.e., increases) unexpectedly, the company's position improves because it will get a higher price for the asset after futures gains or losses are considered; if the basis weakens (i.e., decreases) unexpectedly, the company's position worsens. For a company using a long hedge because it plans to buy the asset, the reverse holds. If the basis strengthens unexpectedly, the company's position worsens because it will pay a higher price for the asset after futures gains and losses are considered; if the basis weakens unexpectedly, the company's position improves.

The asset that gives rise to the company's exposure is sometimes different from the asset underlying the futures contract that is used for hedging. This is known as *cross hedging* and is discussed in the next section. It leads to an increase in basis risk. Define S_2^* as the price of the asset underlying the futures contract at time t_2. As before, S_2 is the price of the asset being hedged at time t_2. By hedging, a company ensures that the price that will be paid (or received) for the asset is

$$S_2 + F_1 - F_2$$

This can be written as

$$F_1 + (S_2^* - F_2) + (S_2 - S_2^*)$$

The terms $S_2^* - F_2$ and $S_2 - S_2^*$ represent the two components of the basis. The $S_2^* - F_2$ term is the basis that would exist if the asset being hedged were the same as the asset underlying the futures contract. The $S_2 - S_2^*$ term is the basis arising from the difference between the two assets.

Choice of Contract

One key factor affecting basis risk is the choice of the futures contract to be used for hedging. This choice has two components:

1. The choice of the asset underlying the futures contract
2. The choice of the delivery month

If the asset being hedged exactly matches an asset underlying a futures contract, the first choice is generally fairly easy. In other circumstances, it is necessary to carry out a careful analysis to determine which of the available futures contracts has futures prices that are most closely correlated with the price of the asset being hedged.

The choice of delivery month can be influenced by several factors. In the examples earlier in this chapter, we assumed that when the expiration of the hedge corresponds to a delivery month, the contract with that delivery month is chosen. In fact, a contract with a later delivery month is usually chosen in these circumstances. The reason is that futures prices can be quite erratic during the delivery month. Also, a long hedger runs the risk of

having to take delivery of the physical asset if the contract is held during the delivery month. Taking delivery can be expensive and inconvenient. (Long hedgers normally prefer to close out the futures contract and buy the asset from their usual suppliers.)

In general, basis risk increases as the time difference between the hedge expiration and the delivery month increases. A good rule of thumb is therefore to choose a delivery month that is as close as possible to, but later than, the expiration of the hedge. Suppose delivery months are March, June, September, and December for futures on a particular asset. For hedge expirations in December, January, and February, the March contract will be chosen; for hedge expirations in March, April, and May, the June contract will be chosen; and so on. This rule of thumb assumes that there is sufficient liquidity in all contracts to meet the hedger's requirements. In practice, liquidity tends to be greatest in short maturity futures contracts. The hedger may therefore, in some situations, be inclined to use short maturity contracts and roll them forward. This strategy is discussed later in the chapter.

Illustrations

Example 3.3 illustrates some of the points made so far in this section. It is March 1. A U.S. company expects to receive 50 million Japanese yen at the end of July. Yen futures contracts offered by the CME Group have delivery months of March, June, September, and December. One contract is for the delivery of 12.5 million yen. The criteria mentioned earlier for the choice of a contract suggest that the September contract be chosen for hedging purposes.

The company shorts four September yen futures contracts on March 1. When the yen are received at the end of July, the company closes out its position. The basis risk arises from uncertainty about the difference between the futures price and the spot price at this time. We suppose that the futures price on March 1 in cents per yen is 1.2800 and that the spot and futures prices when the contract is closed out are 1.2200 and 1.2250 cents per yen, respectively. The basis is −0.0050, and the gain from the futures

Example 3.3 Basis risk in a short hedge

It is March 1. A U.S. company expects to receive 50 million Japanese yen at the end of July. The September futures price for the yen is currently 1.2800 cents per yen. Its hedging strategy is as follows:

1. Short four September yen futures contracts on March 1 at a futures price of 1.2800
2. Close out the contract when the yen arrive at the end of July

One possible outcome is:

Spot price at end of July = 1.2200
September futures price at end of July = 1.2250
Basis at end of July = −0.0050

There are two alternative ways of calculating the net exchange rate after hedging:

Spot price in July + Gain on futures = 1.2200 + 0.0550 = 1.2750
Futures price in March + Basis in July = 1.2800 − 0.0050 = 1.2750

Example 3.4 Basis risk in a long hedge

It is June 8. A company knows that it will need to purchase 20,000 barrels of crude oil some time in October or November. The current December oil futures price is \$88.00 per barrel. Its hedging strategy is as follows:

1. Take a long position in 20 December oil futures contracts on June 8 at a futures price of \$88
2. Close out the contract when ready to purchase the oil

One possible outcome is:

Company is ready to purchase oil on November 10
Spot price on November 10 = \$92
December futures price on November 10 = \$92
Basis on November 10 = \$3

There are two alternative ways of calculating the net cost of oil after hedging:

Spot price on Nov. 10 − Gain on Futures = \$95 − \$4 = \$91
Futures price on June 8 + Basis on November 10 = \$88 + \$3 = \$91

contracts is 0.0550. The effective price obtained in cents per yen is the spot price plus the gain on the futures:

$$1.2200 + 0.0550 = 1.2750$$

This can also be written as the initial futures price plus the basis:

$$1.2800 + (-0.0050) = 1.2750$$

The company receives a total of 50×0.01275 million dollars, or \$637,500.

Example 3.4 considers a long hedge. It is June 8, and a company knows that it will need to purchase 20,000 barrels of crude oil at some time in October or November. Oil futures contracts are traded for delivery every month, and the contract size is 1,000 barrels. Following the criteria indicated, the company decides to use the December contract for hedging. On June 8 it takes a long position in 20 December contracts. At that time, the futures price is \$88.00 per barrel. The company finds that it is ready to purchase the crude oil on November 10. It therefore closes out its futures contract on that date. The basis risk arises from uncertainty as to what the basis will be on the day the contract is closed out. We suppose that the spot price and futures price on November 10 are \$95 per barrel and \$92 per barrel, respectively. The basis is therefore \$3, and the effective price paid is \$91 per barrel, or \$1,820,000 in total.

3.4 CROSS HEDGING

In Examples 3.1 to 3.4, the asset underlying the futures contract is the same as the asset whose price is being hedged. *Cross hedging* occurs when the two assets are different. Consider, for example, an airline that is concerned about the future price of jet fuel. Since jet fuel futures are not actively traded, it might choose to use heating oil futures contracts to hedge its exposure.

The *hedge ratio* is the ratio of the size of the position taken in futures contracts to the size of the exposure. When the asset underlying the futures contract is the same as the asset being hedged it is natural to use a hedge ratio of 1.0. This is the hedge ratio we have used in the examples considered so far. In Example 3.4, for instance, the hedger's exposure was on 20,000 barrels of oil, and futures contracts were entered into for the delivery of exactly this amount of oil.

When cross hedging is used, setting the hedge ratio equal to 1.0 is not always optimal. The hedger should choose a value for the hedge ratio that minimizes the variance of the value of the hedged position. We now consider how the hedger can do this.

Calculating the Minimum Variance Hedge Ratio

The minimum variance hedge ratio depends on the relationship between changes in the spot price and changes in the futures price. Define:

ΔS: Change in spot price, S, during a period of time equal to the life of the hedge

ΔF: Change in futures price, F, during a period of time equal to the life of the hedge

We will denote the minimum variance hedge ratio by h^*. It can be shown that h^* is the slope of the best-fit line from a linear regression of ΔS against ΔF (see Figure 3.2). This result is intuitively reasonable. We would expect h^* to be the ratio of the average change in S for a particular change in F.

The appendix to this chapter provides a review of key statistical concepts: standard deviation, coefficient of correlation, and linear regression. The formula for calculating the best-fit slope in equation (3A.4) gives:

$$h^* = \rho \frac{\sigma_S}{\sigma_F} \tag{3.1}$$

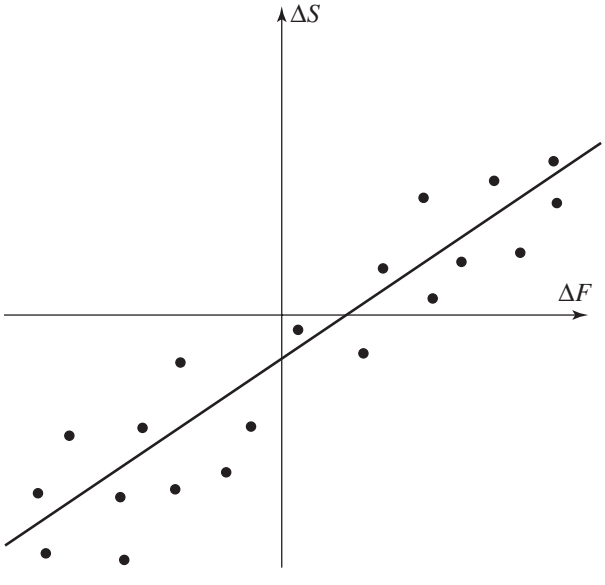

Figure 3.2 Regression of change in spot price against change in futures price

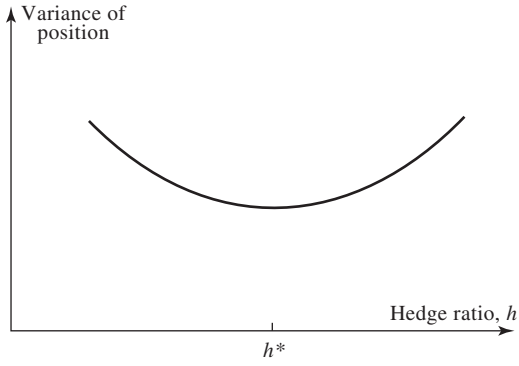

Figure 3.3 Dependence of variance of hedger's position on hedge ratio

where σ_S is the standard deviation of ΔS, σ_F is the standard deviation of ΔF, and ρ is the coefficient of correlation between the two.

Equation (3.1) shows that the optimal hedge ratio is the product of the coefficient of correlation between ΔS and ΔF and the ratio of the standard deviation of ΔS to the standard deviation of ΔF. Figure 3.3 shows how the variance of the value of the hedger's position depends on the hedge ratio chosen.

If $\rho = 1$ and $\sigma_F = \sigma_S$, the hedge ratio, h^*, is 1.0. This result is to be expected, because in this case the futures price mirrors the spot price perfectly. If $\rho = 1$ and $\sigma_F = 2\sigma_S$, the hedge ratio h^* is 0.5. This result is also as expected, because in this case the futures price always changes by twice as much as the spot price. The *hedge effectiveness* can be defined as the proportion of the variance that is eliminated by hedging. This is the R^2 from the regression of ΔS against ΔF and equals ρ^2.

The parameters ρ, σ_F, and σ_S in equation (3.1) are usually estimated from historical data on ΔS and ΔF. (The implicit assumption is that the future will in some sense be like the past.) A number of equal nonoverlapping time intervals are chosen, and the values of ΔS and ΔF for each of the intervals are observed. Ideally, the length of each time interval is the same as the length of the time interval for which the hedge is in effect. In practice, this sometimes severely limits the number of observations that are available, and a shorter time interval is used.

Example 3.5 shows how the results in this section can be used by an airline using heating oil futures to hedge the purchase of jet fuel.[3]

Optimal Number of Contracts

To calculate the number of contracts that should be used in hedging, define:

Q_A: Size of position being hedged (units)

Q_F: Size of one futures contract (units)

N^*: Optimal number of futures contracts for hedging

From equation (3.1), the futures contracts should be on $h^* Q_A$ units of the asset. The

[3] Heating oil futures are more actively traded than jet fuel futures contracts. For an account of how Delta Airlines used heating oil futures to hedge its future purchases of jet fuel, see A. Ness, "Delta Wins on Fuel," *Risk*, June 2001: 8.

Example 3.5 Calculation of the minimimum variance hedge ratio

An airline expects to purchase two million gallons of jet fuel in one month and decides to use heating oil futures for hedging. We suppose that Table 3.2 gives, for 15 successive months, data on the change, ΔS, in the jet fuel price per gallon and the corresponding change, ΔF, in the futures price for the contract on heating oil that would be used for hedging price changes during the month.

To evaluate the minimum variance hedge ratio, we can use the STDEV and CORREL functions in Excel to obtain $\sigma_F = 0.0313$, $\sigma_S = 0.0263$, and $\rho = 0.928$. Equation (3.1) then gives

$$h^* = 0.928 \times \frac{0.0263}{0.0313} = 0.7777$$

Alternatively we can use the SLOPE function in Excel to get this answer directly. (See worksheet on author's website for the calculations.)

This result means that the airline should hedge by taking a position in heating oil futures corresponding to 77.77% of its exposure. The hedge effectiveness is $0.928^2 = 0.862$.

number of futures contracts required is therefore given by

$$N^* = \frac{h^* Q_A}{Q_F} \tag{3.2}$$

In Example 3.5, the optimal hedge ratio, h^*, is 0.7777. Each heating oil contract traded by the CME Group is on 42,000 gallons of heating oil and the airline has an exposure to the price of 2 million gallons of jet fuel. From equation (3.2), the optimal number of contracts is

$$\frac{0.7777 \times 2{,}000{,}000}{42{,}000} = 37.03$$

or, rounding to the nearest whole number, 37.

Tailing the Hedge

When futures are used for hedging, a small adjustment, known as *tailing the hedge*, can be made to allow for the impact of daily settlement. In practice this means that equation (3.2) becomes

$$N^* = \frac{h^* V_A}{V_F} \tag{3.3}$$

where V_A is the dollar value of the position being hedged and V_F is the dollar value of one futures contract (the futures price times Q_F). Suppose that in Example 3.5 the futures price and the spot price are 1.99 and 1.94 dollars per gallon, respectively. Then $V_A = 2{,}000{,}000 \times 1.94 = 3{,}880{,}0000$, while $V_F = 42{,}000 \times 1.99 = 83{,}580$, so that the optimal number of contracts is

$$\frac{0.7777 \times 3{,}880{,}000}{83{,}580} = 36.10$$

Table 3.2 Data to calculate minimum variance hedge ratio when heating oil futures contract is used to hedge purchase of jet fuel

Month i	*Change in heating oil futures price per gallon* (ΔF)	*Change in jet fuel price per gallon* (ΔS)
1	0.021	0.029
2	0.035	0.020
3	−0.046	−0.044
4	0.001	0.008
5	0.044	0.026
6	−0.029	−0.019
7	−0.026	−0.010
8	−0.029	−0.007
9	0.048	0.043
10	−0.006	0.011
11	−0.036	−0.036
12	−0.011	−0.018
13	0.019	0.009
14	−0.027	−0.032
15	0.029	0.023

If we round this to the nearest whole number, the optimal number of contracts is now 36 rather than 37. The effect of tailing the hedge is to multiply the hedge ratio in equation (3.2) by the ratio of the spot price to the futures price. Theoretically, the futures position used for hedging should then be adjusted as V_A and V_F change, but in practice this usually makes very little difference.

If forward contracts rather than futures are used, there is no daily settlement and equation (3.2) should be used.

3.5 STOCK INDEX FUTURES

We now move on to consider stock index futures and how they are used to hedge or manage exposures to equity prices.

A *stock index* tracks changes in the value of a hypothetical portfolio of stocks. The weight of a stock in the portfolio at a particular time equals the proportion of the hypothetical portfolio invested in the stock at that time. The percentage increase in the stock index over a small interval of time is set equal to the percentage increase in the value of the hypothetical portfolio. Dividends are usually not included in the calculation, so that the index tracks the capital gain/loss from investing in the portfolio.[4]

[4] An exception to this is a *total return index*. This is calculated by assuming that dividends on the hypothetical portfolio are reinvested in the portfolio.

If the hypothetical portfolio of stocks remains fixed, the weights assigned to individual stocks in the portfolio do not remain fixed. When the price of one particular stock in the portfolio rises more sharply than others, more weight is automatically given to that stock. Sometimes indices are constructed from a hypothetical portfolio consisting of one of each of a number of stocks. The weights assigned to the stocks are then proportional to their market prices, with adjustments being made when there are stock splits. Other indices are constructed so that weights are proportional to market capitalization (stock price × number of shares outstanding). The underlying portfolio is then automatically adjusted to reflect stock splits, stock dividends, and new equity issues.

Stock Indices

Table 3.3 gives futures prices for contracts on three different stock indices on July 13, 2012.

The *Dow Jones Industrial Average* is based on a portfolio consisting of 30 blue-chip stocks in the United States. The weights given to the stocks are proportional to their prices. The CME Group trades two futures contracts on the index. One is on $10 times the index. The other (the Mini DJ Industrial Average) is on $5 times the index. The Mini contract trades most actively.

The *Standard & Poor's 500* (S&P 500) *Index* is based on a portfolio of 500 different stocks: 400 industrials, 40 utilities, 20 transportation companies, and 40 financial institutions. The weights of the stocks in the portfolio at any given time are proportional to their market capitalizations. The stocks are those of large publicly held companies that trade on NYSE Euronext or NASDAQ OMX. The CME Group trades two futures contracts on the S&P 500. One is on $250 times the index; the other (the Mini S&P 500 contract) is on $50 times the index. The Mini contract trades most actively.

The *NASDAQ-100* is based on 100 stocks using the National Association of Securities Dealers Automatic Quotations Service. The CME Group trades two contracts. One is on $100 times the index; the other (the Mini NASDAQ-100 contract) is on $20 times the index. The Mini contract trades most actively.

Table 3.3 Futures quotes for a selection of CME Group contracts on stock indices on July 13, 2012

	Open	*High*	*Low*	*Prior settlement*	*Last trade*	*Change*	*Volume*
Mini Dow Jones Industrial Average, $5 times index							
Sept. 2012	12,500	12,714	12,500	12,502	12,713	+211	100,898
Dec. 2012	12,501	12,625	12,501	12,424	12,625	+201	9
Mini S&P 500, $50 times index							
Sept. 2012	1329.25	1353.25	1328.75	1329.25	1351.50	+22.25	1,437,896
Dec. 2012	1323.00	1346.00	1322.00	1322.00	1344.75	+22.75	1,907
Mini NASDAQ-100, $20 times index							
Sept. 2012	2537.50	2584.75	2537.50	2537.75	2584.00	+46.25	156,547
Dec. 2012	2538.75	2575.00	2538.75	2531.00	2575.00	+44.00	2

As mentioned in Chapter 2, futures contracts on stock indices are settled in cash, not by delivery of the underlying asset. All contracts are marked to market to either the opening price or the closing price of the index on the last trading day, and the positions are then deemed to be closed. For example, contracts on the S&P 500 are closed out at the opening price of the S&P 500 index on the third Friday of the delivery month.

Hedging an Equity Portfolio

Stock index futures can be used to hedge a well-diversified equity portfolio. Define:

V_A: Current value of the portfolio

V_F: Current value of one futures contract (the futures price times the contract size)

If the portfolio mirrors the index, a hedge ratio very close to 1.0 is clearly appropriate, and equation (3.3) shows that the number of futures contracts that should be shorted is

$$N^* = \frac{V_A}{V_F} \tag{3.4}$$

Suppose, for example, that a portfolio worth \$5.05 million mirrors the S&P 500. The index futures price is 1,010 and each futures contract is on \$250 times the index. In this case, $V_A = 5{,}050{,}000$ and $V_F = 1{,}010 \times 250 = 252{,}500$, so that $5{,}050{,}000/252{,}500 = 20$ contracts should be shorted to hedge the portfolio.

When the portfolio does not exactly mirror the index, we can use the parameter beta (β) from the capital asset pricing model to determine the appropriate number of contracts to short. As explained in the appendix to this chapter, the beta of an asset is the slope of the best-fit line when the return on the asset is regressed against the return of a well-diversified stock index. When the beta of a portfolio equals 1.0, the return on the portfolio tends to mirror the return on the index; when $\beta = 2.0$, the changes in the return on the portfolio tend to be twice as great as the corresponding changes in the return from the index; when $\beta = 0.5$, they tend to be half as great; and so on.

A portfolio with a β of 2.0 is twice as sensitive to index movements as a portfolio with a beta of 1.0. It is therefore necessary to use twice as many contracts to hedge the portfolio. Similarly, a portfolio with a beta of 0.5 is half as sensitive to the index as a portfolio with a beta of 1.0 and we should use half as many contracts to hedge it. In general, we adjust equation (3.4) for a portfolio with a beta different from 1.0 as follows:

$$N^* = \beta \frac{V_A}{V_F} \tag{3.5}$$

This formula assumes that the maturity of the futures contract is close to the maturity of the hedge.

Comparing equation (3.5) with equation (3.3), we see that they imply $h^* = \beta$. This is not surprising. The hedge ratio h^* is the slope of the best-fit line when changes in the portfolio are regressed against changes in the futures price of the index. Beta (β) is the slope of the best-fit line when the return from the portfolio is regressed against the return from the the index. The two slopes are very similar.

We will show that equation (3.5) gives good results by extending our earlier example. Suppose that a futures contract with four months to maturity is used to hedge the value of a portfolio over the next three months in the following situation:

S&P 500 index = 1,000
S&P 500 futures price = 1,010
Value of portfolio = \$5,050,000
Risk-free interest rate = 4% per annum
Dividend yield on index = 1% per annum
Beta of portfolio = 1.5

One futures contract is for delivery of \$250 times the index. As before, $V_F = 250 \times 1{,}010 = 252{,}500$. From equation (3.5), the number of futures contracts that should be shorted to hedge the portfolio is

$$1.5 \times \frac{5{,}050{,}000}{252{,}500} = 30$$

Suppose the index turns out to be 900 in three months and the futures price is 902. The gain from the short futures position is then

$$30 \times (1{,}010 - 902) \times 250 = \$810{,}000$$

The loss on the index is 10%. The index pays a dividend of 1% per annum, or 0.25% per three months. When dividends are taken into account, an investor in the index would therefore earn −9.75% over the three-month period. As shown in the appendix to this chapter, the capital asset pricing model gives

Expected return on portfolio = Risk-free interest rate
+ 1.5 × (Return on index − Risk-free interest rate)

The risk-free interest rate is approximately 1% per three months. It follows that the expected return (%) on the portfolio during the three months is

$$1.0 + [1.5 \times (-9.75 - 1.0)] = -15.125$$

The expected value of the portfolio (inclusive of dividends) at the end of the three months is therefore

$$\$5{,}050{,}000 \times (1 - 0.15125) = \$4{,}286{,}187$$

It follows that the expected value of the hedger's position, including the gain on the hedge, is

$$\$4{,}286{,}187 + \$810{,}000 = \$5{,}096{,}187$$

Table 3.4 summarizes these calculations together with similar calculations for other values of the index at maturity. It can be seen that the total value of the hedger's position in three months is almost independent of the value of the index.

One thing we have not covered in this example is the relationship between futures prices and spot prices. We will see in Chapter 5 that the 1,010 assumed for the futures

Table 3.4 Performance of stock index hedge

Value of index in three months:	900	950	1,000	1,050	1,100
Futures price of index today:	1,010	1,010	1,010	1,010	1,010
Futures price of index in three months:	902	952	1,003	1,053	1,103
Gain on futures position ($):	810,000	435,000	52,500	−322,500	−697,500
Return on market:	−9.750%	−4.750%	0.250%	5.250%	10.250%
Expected return on portfolio:	−15.125%	−7.625%	−0.125%	7.375%	14.875%
Expected portfolio value in three months including dividends ($):	4,286,187	4,664,937	5,043,687	5,422,437	5,801,187
Total value of position in three months ($):	5,096,187	5,099,937	5,096,187	5,099,937	5,103,687

price today is roughly what we would expect given the interest rate and dividend we are assuming. The same is true of the futures prices in three months shown in Table 3.4.[5]

Reasons for Hedging an Equity Portfolio

Table 3.4 shows that the hedging procedure results in a value for the hedger's position at the end of the three months being about 1% higher than at the beginning of the three months. There is no surprise here. The risk-free rate is 4% per annum or 1% per three months. The hedge results in the investor's position growing at the risk-free rate.

It is natural to ask why the hedger should go to the trouble of using futures contracts. To earn the risk-free interest rate, the hedger can simply sell the portfolio and invest the proceeds in risk-free instruments such as Treasury bills.

One answer to this question is that hedging can be justified if the hedger feels that the stocks in the portfolio have been chosen well. In these circumstances, the hedger might be very uncertain about the performance of the market as a whole, but confident that the stocks in the portfolio will outperform the market (after appropriate adjustments have been made for the beta of the portfolio). A hedge using index futures removes the risk arising from market moves and leaves the hedger exposed only to the performance of the portfolio relative to the market. (This will be discussed shortly.) Another reason for hedging may be that the hedger is planning to hold a portfolio for a long period of time and requires short-term protection in an uncertain market situation. The alternative strategy of selling the portfolio and buying it back later might involve unacceptably high transaction costs.

Changing the Beta of a Portfolio

In the example in Table 3.4, the beta of the hedger's portfolio is reduced to zero so that the expected return is independent of the performance of the index. Sometimes futures

[5] The calculations in Table 3.4 assume that the dividend yield on the index is predictable, the risk-free interest rate remains constant, and the return on the index over the three-month period is perfectly correlated with the return on the portfolio. In practice, these assumptions do not hold perfectly, and the hedge works rather less well than is indicated by Table 3.4.

contracts are used to change the beta of a portfolio to some value other than zero. Continuing with our earlier example:

S&P 500 index = 1,000
S&P 500 futures price = 1,010
Value of portfolio = $5,050,000
Beta of portfolio = 1.5

As before, $V_F = 250 \times 1{,}010 = 252{,}500$ and a complete hedge requires

$$1.5 \times \frac{5{,}050{,}000}{252{,}500} = 30$$

contracts to be shorted. To reduce the beta of the portfolio from 1.5 to 0.75, the number of contracts shorted should be 15 rather than 30; to increase the beta of the portfolio to 2.0, a long position in 10 contracts should be taken; and so on. In general, to change the beta of the portfolio from β to β^*, where $\beta > \beta^*$, a short position in

$$(\beta - \beta^*)\frac{V_A}{V_F}$$

contracts is required. When $\beta < \beta^*$, a long position in

$$(\beta^* - \beta)\frac{V_A}{V_F}$$

contracts is required.

Locking in the Benefits of Stock Picking

Suppose you consider yourself to be good at picking stocks that will outperform the market. You own a single stock or a small portfolio of stocks. You do not know how well the market will perform over the next few months, but you are confident that your portfolio will do better than the market. What should you do?

You should short $\beta V_A/V_F$ index futures contracts, where β is the beta of your portfolio, V_A is the total value of the portfolio, and V_F is the current value of one index futures contract. If your portfolio performs better than a well-diversified portfolio with the same beta, you will then make money.

Consider an investor who in April holds 20,000 shares of a company, each worth $100. The investor feels that the market will be very volatile over the next three months but that the company has a good chance of outperforming the market. The investor decides to use the August futures contract on the S&P 500 to hedge the market's return during the three-month period. The β of the company is estimated at 1.1. Suppose that the current futures price for the August contract on the S&P 500 is 900. Each contract is for delivery of $250 times the index. In this case, $V_A = 20{,}000 \times 100 = 2{,}000{,}000$ and $V_F = 900 \times 250 = 225{,}000$. The number of contracts that should be shorted is therefore

$$1.1 \times \frac{2{,}000{,}000}{225{,}000} = 9.78$$

Rounding to the nearest integer, the investor shorts 10 contracts, closing out the

position in July. Suppose that the company's stock falls to \$90 and the futures price of the S&P 500 falls to 750. The investor loses $20{,}000 \times (\$100 - \$90) = \$200{,}000$ on the stock, while gaining $10 \times 250 \times (900 - 750) = \$375{,}000$ on the futures contracts.

The overall gain to the investor in this case is \$175,000 because the company's stock did not go down by as much as a well-diversified portfolio with a β of 1.1. If the market had gone up and the company's stock went up by more than a portfolio with a β of 1.1 (as expected by the investor), then a profit would be made in this case as well.

3.6 STACK AND ROLL

Sometimes the expiration date of the hedge is later than the delivery dates of all the futures contracts that can be used. The hedger must then roll the hedge forward by closing out one futures contract and taking the same position in a futures contract with a later delivery date. Hedges can be rolled forward many times. Consider a company that wishes to use a short hedge to reduce the risk associated with the price to be received for an asset at time T. If there are futures contracts 1, 2, 3, ..., n (not all necessarily in existence at the present time) with progressively later delivery dates, the company can use the following strategy:

Time t_1: Short futures contract 1

Time t_2: Close out futures contract 1
Short futures contract 2

Time t_3: Close out futures contract 2
Short futures contract 3
⋮

Time t_n: Close out futures contract $n - 1$
Short futures contract n

Time T: Close out futures contract n

Suppose that in April 2013 a company realizes that it will have 1 million barrels of oil to sell in June 2014 and decides to hedge its risk with a hedge ratio of 1.0. (In this example, we do not make the "tailing" adjustment described in Section 3.4.) The current spot price is \$89. Although futures contracts are traded with maturities stretching several years into the future, we suppose that only the first six delivery months have sufficient liquidity to meet the company's needs. The company therefore shorts 1,000 October 2013 contracts. In September 2013, it rolls the hedge forward into the March 2014 contract. In February 2014, it rolls the hedge forward again into the July 2014 contract.

One possible outcome is shown in Table 3.5. The October 2013 contract is shorted at \$88.20 per barrel and closed out at \$87.40 per barrel for a profit of \$0.80 per barrel; the March 2014 contract is shorted at \$87.00 per barrel and closed out at \$86.50 per barrel for a profit of \$0.50 per barrel. The July 2014 contract is shorted at \$86.30 per barrel and closed out at \$85.90 per barrel for a profit of \$0.40 per barrel. The final spot price is \$86.

The dollar gain per barrel of oil from the short futures contracts is

$$(88.20 - 87.40) + (87.00 - 86.50) + (86.30 - 85.90) = 1.70$$

Table 3.5 Data for the example on rolling oil hedge forward

Date	*Apr. 2013*	*Sept. 2013*	*Feb. 2014*	*June 2014*
Oct. 2013 futures price	88.20	87.40		
Mar. 2014 futures price		87.00	86.50	
July 2014 futures price			86.30	85.90
Spot price	89.00			86.00

The oil price declined from \$89 to \$86. Receiving only \$1.70 per barrel compensation for a price decline of \$3.00 may appear unsatisfactory. However, we cannot expect total compensation for a price decline when futures prices are below spot prices. The best we can hope for is to lock in the futures price that would be applicable to a contract maturing in June 2014.

In practice, a company usually has an exposure every month to the underlying asset and uses a one-month futures contract for hedging because it is the most liquid. Initially it enters into (''stacks'') sufficient contracts to cover its exposure to the end of its hedging horizon. One month later, it closes out all the contracts and ''rolls'' them into new one-month contracts to cover its new exposure, and so on.

As described in Business Snapshot 3.2, a German company, Metallgesellschaft, followed this strategy in the early 1990s to hedge contracts it had entered into to supply commodities at a fixed price. It ran into difficulties because the prices of the commodities declined so that there were immediate cash outflows on the futures and the expectation of eventual gains on the contracts. This mismatch between the timing of the cash flows on hedge and the timing of the cash flows from the position being hedged led to liquidity problems that could not be handled. The moral of the story is that potential liquidity problems should always be considered when a hedging strategy is being planned.

SUMMARY

This chapter has discussed various ways in which a company can take a position in futures contracts to offset an exposure to the price of an asset. If the exposure is such that the company gains when the price of the asset increases and loses when the price of the asset decreases, a short hedge is appropriate. If the exposure is the other way round (i.e., the company gains when the price of the asset decreases and loses when the price of the asset increases), a long hedge is appropriate.

Hedging is a way of reducing risk. As such, it should be welcomed by most executives. In reality, there are a number of theoretical and practical reasons why companies do not hedge. On a theoretical level, we can argue that shareholders, by holding well-diversified portfolios, can eliminate many of the risks faced by a company. They do not require the company to hedge these risks. On a practical level, a company may find that it is increasing rather than decreasing risk by hedging if none of its competitors does so. Also, a treasurer may fear criticism from other executives if the company makes a gain from movements in the price of the underlying asset and a loss on the hedge.

Business Snapshot 3.2 Metallgesellschaft: Hedging gone awry

Sometimes rolling hedges forward can lead to cash flow pressures. This problem was illustrated dramatically by the activities of a German company, Metallgesellschaft (MG), in the early 1990s.

MG sold a huge volume of 5- to 10-year heating oil and gasoline fixed-price supply contracts to its customers at 6 to 8 cents above market prices. It hedged its exposure with long positions in short-dated futures contracts that were rolled forward. As it turned out, the price of oil fell and there were margin calls on the futures positions. Considerable short-term cash flow pressures were placed on MG. The members of MG who devised the hedging strategy argued that these short-term cash outflows were offset by positive cash flows that would ultimately be realized on the long-term fixed-price contracts. However, the company's senior management and its bankers became concerned about the huge cash drain. As a result, the company closed out all the hedge positions and agreed with its customers that the fixed-price contracts would be abandoned. The outcome was a loss to MG of $1.33 billion.

An important concept in hedging is basis risk. The basis is the difference between the spot price of an asset and its futures price. Basis risk arises from a hedger's uncertainty as to what the basis will be at maturity of the hedge.

The hedge ratio is the ratio of the size of the position taken in futures contracts to the size of the exposure. It is not always optimal to use a hedge ratio of 1.0. If the hedger wishes to minimize the variance of a position, a hedge ratio different from 1.0 may be appropriate. The optimal hedge ratio is the slope of the best-fit line obtained when changes in the spot price are regressed against changes in the futures price.

Stock index futures can be used to hedge the systematic risk in an equity portfolio. The number of futures contracts required is the beta of the portfolio multiplied by the ratio of the value of the portfolio to the value of one futures contract. Stock index futures can also be used to change the beta of a portfolio without changing the stocks comprising the portfolio.

When there is no liquid futures contract that matures later than the expiration of the hedge, a strategy known as stack and roll may be appropriate. This involves entering into a sequence of futures contracts. When the first futures contract is near expiration, it is closed out and the hedger enters into a second contract with a later delivery month. When the second contract is close to expiration, it is closed out and the hedger enters into a third contract with a later delivery month; and so on. The result of all this is the creation of a long-dated futures contract by trading a series of short-dated contracts.

FURTHER READING

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