SECOND EDITION

Options, Futures, and Other Derivative Securities

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Introduction

A *derivative security* is a security whose value depends on the values of other more basic underlying variables. In recent years, derivative securities have become increasingly important in the field of finance. Futures and options are now actively traded on many different exchanges. Forward contracts, swaps, and many different types of options are regularly traded outside of exchanges by financial institutions and their corporate clients in what are termed the *over-the-counter* markets. Other more specialized derivative securities often form part of a bond or stock issue.

Derivative securities are also known as *contingent claims*, and these two terms will be used interchangeably throughout this book. Very often the variables underlying derivative securities are the prices of traded securities. A stock option, for example, is a derivative security whose value is contingent on the price of a stock. However, as we shall see, derivative securities can be contingent on almost any variable, from the price of hogs to the amount of snow falling at a certain ski resort.

This book has two objectives. The first is to explore the properties of those derivative securities that are commonly encountered in practice; the second is to provide a theoretical framework within which all derivative securities can be valued

and hedged. In this opening chapter, we take a first look at forward contracts, futures contracts, and options. In later chapters, these securities and the way they are traded will be discussed in more detail.

1.1 FORWARD CONTRACTS

A *forward contract* is a particularly simple derivative security. It is an agreement to buy or sell an asset at a certain future time for a certain price. The contract is usually between two financial institutions or between a financial institution and one of its corporate clients. It is not normally traded on an exchange.

One of the parties to a forward contract assumes a *long position* and agrees to buy the underlying asset on a certain specified future date for a certain specified price. The other party assumes a *short position* and agrees to sell the asset on the same date for the same price. The specified price in a forward contract will be referred to as the *delivery price*. At the time the contract is entered into, the delivery price is chosen so that the value of the forward contract to both parties is zero.[1] This means that it costs nothing to take either a long or a short position.

A forward contract is settled at maturity. The holder of the short position delivers the asset to the holder of the long position in return for a cash amount equal to the delivery price. A key variable determining the value of a forward contract is the market price of the asset. As already mentioned, a forward contract is worth zero when it is first entered into. Later it can have a positive or a negative value depending on movements in the price of the asset. For example, if the price of the asset rises sharply soon after the initiation of the contract, the value of a long position in the forward contract becomes positive and the value of a short position in the forward contract becomes negative.

THE FORWARD PRICE

The *forward price* for a certain contract is defined as the delivery price which would make that contract have zero value. The forward price and the delivery price are therefore equal at the time the contract is entered into. As time passes, the forward price is liable to change while the delivery price, of course, remains the same. The two are not therefore equal, except by chance, at any time after the start of the contract. Generally, the forward price at any given time varies with the maturity of the contract being considered. For example, the forward price for a contract to buy or sell in 3 months is typically different from that for a contract to buy or sell in 6 months.

[1] In Chapter 3 we explain the way in which this delivery price can be calculated.

TABLE 1.1 Spot and Forward Foreign Exchange Quotes, September 11, 1991

Spot	1.7280
30-day forward	1.7208
90-day forward	1.7090
180-day forward	1.6929

Corporations frequently enter into forward contracts on foreign exchange. Consider the quotes shown in Table 1.1 for the pound sterling–U.S. dollar exchange rate on September 11, 1991. The first quote indicates that, ignoring commissions and other transactions costs, sterling can be bought or sold in the spot market (that is, for virtually immediate delivery) at the rate of \$1.7280 per pound; the second quote indicates that the forward price (or forward exchange rate) for a contract to buy or sell sterling in 30 days is \$1.7208 per pound; the third quote indicates that the forward price for a contract to buy or sell sterling in 90 days is \$1.7090 per pound; and so on.

Payoffs from Forward Contracts

The payoff from a long position in a forward contract on one unit of an asset is

$$S_T - K$$

where K is the delivery price and S_T is the spot price of the asset at maturity of the contract. This is because the holder of the contract is obligated to buy an asset worth S_T for K. Similarly, the payoff from a short position in a forward contract on one unit of an asset is

$$K - S_T$$

These payoffs can be positive or negative. They are illustrated in Figure 1.1. Since it costs nothing to enter into a forward contract, the payoff from the contract is also the investor's total gain or loss from the contract.

1.2 FUTURES CONTRACTS

A *futures contract*, like a forward contract, is an agreement between two parties to buy or sell an asset at a certain time in the future for a certain price. Unlike forward contracts, futures contracts are normally traded on an exchange. To make trading possible, the exchange specifies certain standardized features of the contract. As

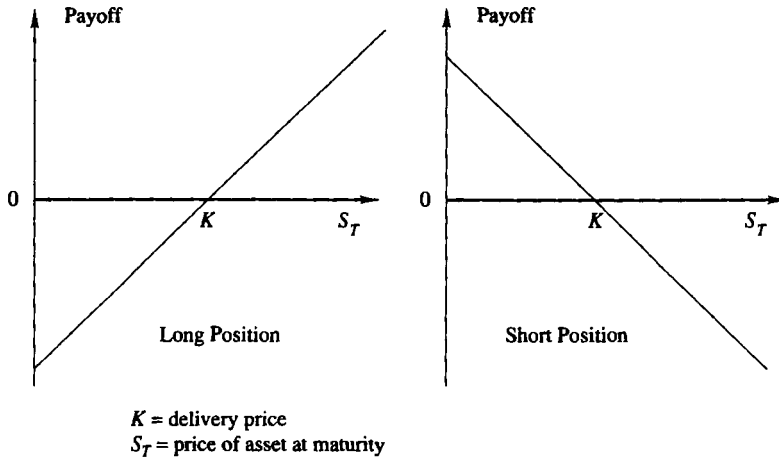

Figure 1.1 Payoffs from Forward Contracts.

the two parties to the contract do not necessarily know each other, the exchange also provides a mechanism which gives the two parties a guarantee that the contract will be honored.

The largest exchanges on which futures contracts are traded are the Chicago Board of Trade (CBOT) and the Chicago Mercantile Exchange (CME). On these and other exchanges, a very wide range of commodities and financial assets form the underlying assets in the various contracts. The commodities include pork bellies, live cattle, sugar, wool, lumber, copper, aluminum, gold, and tin. The financial assets include stock indices, currencies, Treasury bills, and bonds.

One way in which a futures contract is different from a forward contract is that an exact delivery date is not usually specified. The contract is referred to by its delivery month, and the exchange specifies the period during the month when delivery must be made. For commodities, the delivery period is often the whole month. The holder of the short position has the right to choose the time during the delivery period when he or she will make delivery. Usually, contracts with several different delivery months are traded at any one time. The exchange specifies the amount of the asset to be delivered for one contract; how the futures price is to be quoted; and, possibly, limits on the amount by which the futures price can move in any one day. In the case of a commodity, the exchange also specifies the product quality and the delivery location. Consider, for example, the wheat futures contract currently traded on the Chicago Board of Trade. The size of the contract is 5,000 bushels. Contracts for five delivery months (March, May, July, September, and December) are available for up to one year into the future. The exchange specifies the grades of wheat that can be delivered and the places where delivery can be made.

Futures prices are regularly reported in the financial press. Suppose that, on September 1, the December futures price of gold is quoted at $500. This is the price, exclusive of commissions, at which investors can agree to buy or sell gold for December delivery. It is determined on the floor of the exchange in the same way as other prices (that is, by the laws of supply and demand). If more investors want to go long than to go short, the price goes up; if the reverse is true, the price goes down.[2]

Further details on issues such as margin requirements, daily settlement procedures, delivery procedures, bid-ask spreads, and the role of the exchange clearinghouse will be given in the next chapter.

1.3 OPTIONS

Options on stocks were first traded on an organized exchange in 1973. Since then, there has been a dramatic growth in options markets. Options are now traded on many different exchanges throughout the world. Huge volumes of options are also traded over the counter by banks and other financial institutions. The underlying assets include stocks, stock indices, foreign currencies, debt instruments, commodities, and futures contracts.

There are two basic types of options. A *call option* gives the holder the right to buy the underlying asset by a certain date for a certain price. A *put option* gives the holder the right to sell the underlying asset by a certain date for a certain price. The price in the contract is known as the *exercise price* or *strike price*; the date in the contract is known as the *expiration date, exercise date*, or *maturity*. *American options* can be exercised at any time up to the expiration date. *European options* can only be exercised on the expiration date itself.[3] Most of the options that are traded on exchanges are American. However, European options are generally easier to analyze than American options, and some of the properties of an American option are frequently deduced from those of its European counterpart.

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 forwards and futures where the holder is obligated to buy or sell the underlying asset. Note that, whereas it costs nothing to enter into a forward or futures contract, an investor must pay to purchase an option contract.

[2]As we will see in Chapter 3, a futures price can sometimes be related to the price of the underlying asset (gold, in this case).

[3]Note that the terms *American* and *European* do not refer to the location of the option or the exchange. Some options trading on North American exchanges are European.

EXAMPLES

Consider the situation of an investor who buys 100 European call options on IBM stock with a strike price of $140. Suppose that the current stock price is $138, the expiration date of the option is in 2 months, and the option price is $5. Since the options are European, the investor can exercise only on the expiration date. If the stock price on this date is less than $140, he or she will clearly choose not to exercise. (There is no point in buying for $140 a stock that has a market value of less than $140.) In these circumstances the investor loses the whole of the initial investment of $500. If the stock price is above $140 on the expiration date, the options will be exercised. Suppose, for example, that the stock price is $155. By exercising the options, the investor is able to buy 100 shares for $140 per share. If the shares are sold immediately, the investor makes a gain of $15 per share or $1,500, ignoring transactions costs. When the initial cost of the options is taken into account, the net profit to the investor is $10 per option, or $1,000. (This calculation ignores the time value of money.) Figure 1.2 shows the way in which the investor's net profit or loss per option varies with the terminal stock price. Note that in some cases the investor exercises the options but takes a loss overall. Consider the situation when the stock price is $142 on the expiration date. The investor exercises the options but takes a loss of $300 overall. This is better than the loss of $500 that would be incurred if the options were not exercised.

Whereas the purchaser of a call option is hoping that the stock price will increase, the purchaser of a put option is hoping that it will decrease. Consider an investor who buys 100 European put options on Exxon with a strike price of $90. Suppose that the current stock price is $86, the expiration date of the option is in

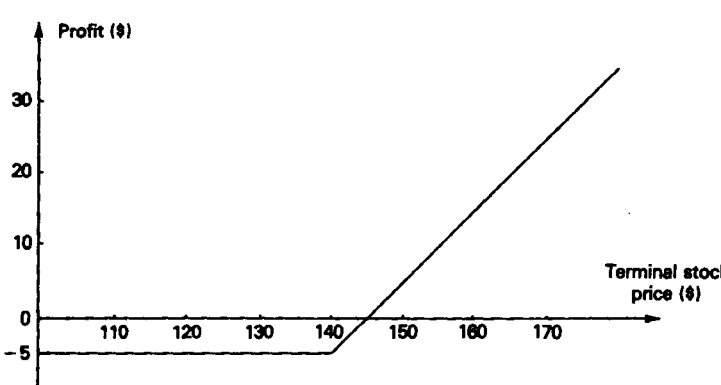

Figure 1.2 Profit from Buying an IBM European Call Option. Option Price = $5; Strike Price = $140.

3 months, and the option price is $7. Since the options are European, they will be exercised only if the stock price is below $90 at the expiration date. Suppose that the stock price is $65 on this date. The investor can buy 100 shares for $65 per share and, under the terms of the put option, sell the same stock for $90 to realize a gain of $25 per share, or $2,500. (Again, transactions costs are ignored.) When the initial cost of the option is taken into account, the investor's net profit is $18 per option, or $1,800. Of course, if the final stock price is above $90, the put option expires worthless and the investor loses $7 per option, or $700. Figure 1.3 shows the way in which the investor's profit or loss per option varies with the terminal stock price.

As already mentioned, stock options are generally American rather than European. This means that the investors in the examples just given do not have to wait until the expiration date before exercising the options. We will see later that there are some circumstances under which it is optimal to exercise American options prior to maturity.

Option Positions

There are two sides to every option contract. On one side is the investor who has taken the long position (i.e., has bought the option). On the other side is the investor who has taken a short position (i.e., has sold or *written* the option). The writer of an option receives cash up front but has potential liabilities later. His or her profit or loss is the reverse of that for the purchaser of the option. Figures 1.4 and 1.5 show the variation of the profit and loss with the final stock price for writers of the options considered in figures 1.2 and 1.3.

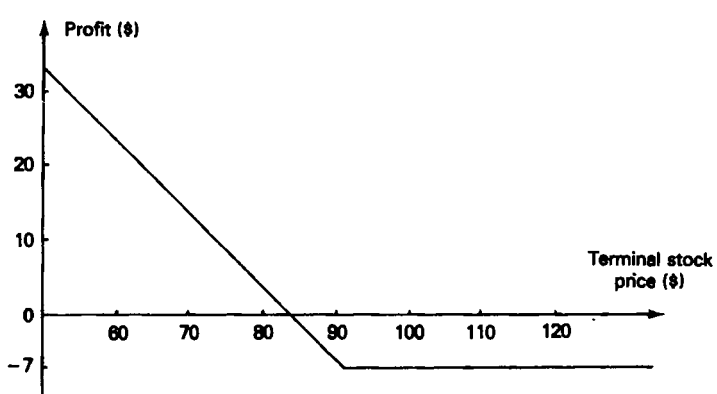

Figure 1.3 Profit from Buying an Exxon European Put Option. Option Price = $7; Strike Price = $90.

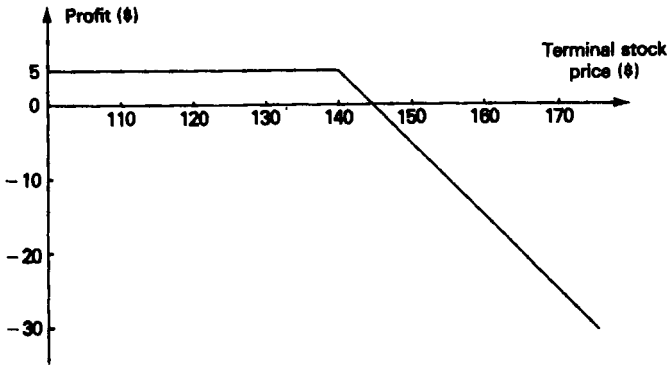

Figure 1.4 Profit from Writing an IBM European Call Option. Option Price = $5; Strike Price = $140.

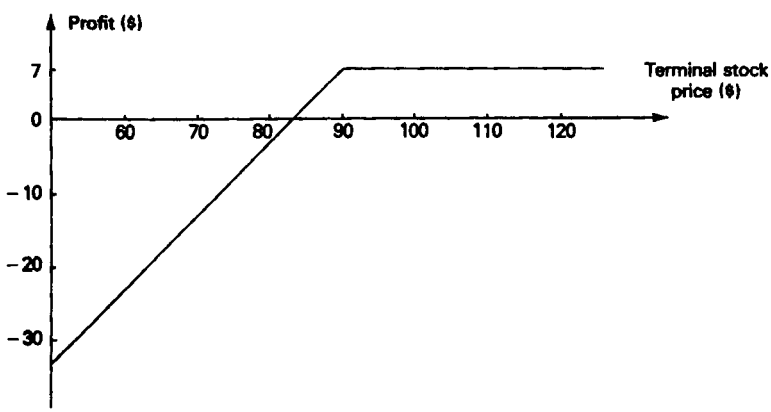

Figure 1.5 Profit from Writing an Exxon European Put Option. Option Price = $7; Strike Price = $90.

Four basic option positions are possible:

1. A long position in a call option
2. A long position in a put option
3. A short position in a call option
4. A short position in a put option

PAYOFFS

It is often useful to characterize European option positions in terms of the payoff to the investor at maturity. The initial cost of the option is then not included

in the calculation. If X is the strike price and S_T is the final price of the underlying asset, the payoff from a long position in a European call option is

$$\max(S_T - X, 0)$$

This reflects the fact that the option will be exercised if $S_T > X$ and will not be exercised if $S_T \leq X$. The payoff to the holder of a short position in the European call option is

$$-\max(S_T - X, 0)$$

or

$$\min(X - S_T, 0)$$

The payoff to the holder of a long position in a European put option is

$$\max(X - S_T, 0)$$

and the payoff from a short position in a European put option is

$$-\max(X - S_T, 0)$$

or

$$\min(S_T - X, 0)$$

Figure 1.6 illustrates these payoffs graphically.

1.4 OTHER DERIVATIVE SECURITIES

In recent years, banks and other financial institutions have been very imaginative in designing nonstandard derivative securities to meet the needs of clients. Sometimes these are sold by financial institutions directly to their corporate clients. On other occasions, they are added to bond or stock issues to make these issues more attractive to investors. Some of the securities are simply combinations of simpler contracts, such as forwards and options. Others are far more complex. The possibilities for designing new interesting derivative securities seems to be virtually limitless. In this section, we give a few examples.

Interest Rate Caps

An interest rate cap is designed to provide corporate borrowers with protection against the rate of interest on a floating-rate loan going above some level. This level is known as the *cap rate*. If the rate of interest on the loan does go above the cap rate, the seller of the cap provides the difference between the interest on the loan and the interest that would be required if the cap rate applied. Suppose

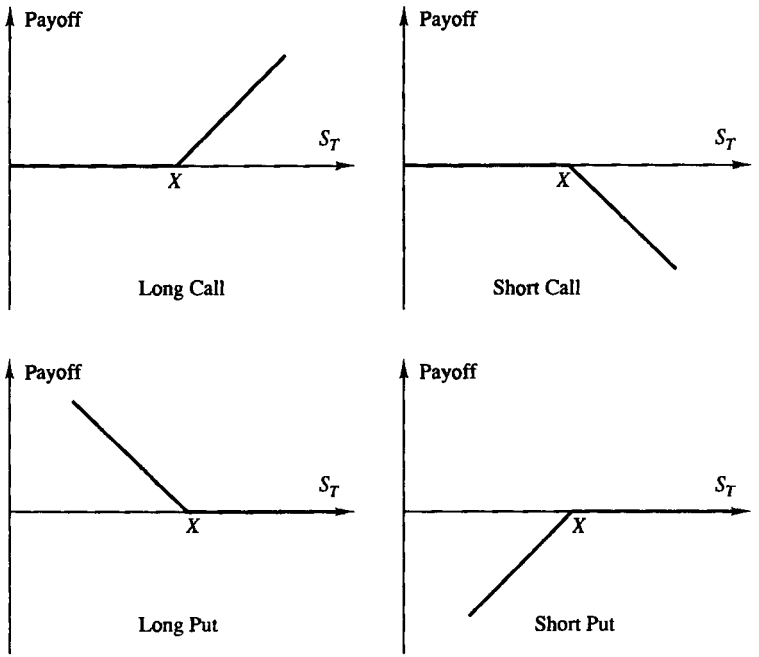

Figure 1.6 Payoffs from Positions in European Options

the loan is for $10 million, the cap rate is 12 percent per annum, and that for a particular 3-month period during the life of the cap, the floating rate applicable to the loan turns out to be 14 percent per annum. The purchaser of the cap would receive $50,000 (= 1/4 of 2% of $10 million) from the seller of the cap at the end of the 3-month period. Occasionally caps are structured to guarantee that the average rate paid during the life of the loan (rather than the rate at any particular time) will not go above a certain level. Caps will be discussed further in Chapter 15.

Standard Oil's Bond Issue

An example of a derivative security added to a bond issue is provided by Standard Oil's issue of zero-coupon bonds in 1986. In addition to the bond's $1,000 maturity value, the company promised to pay an amount based on the price of oil at maturity of the bond. This additional amount was equal to the product of 170 and the excess (if any) of the price of a barrel of oil at maturity over $25. However, the maximum additional amount paid was restricted to $2,550 (which

corresponds to a price of $40 per barrel). The bonds provided holders with a stake in a commodity that was critically important to the fortunes of the company. If the price of the commodity went up, the company was in a good position to provide the bondholder with the additional payment.

ICONs

In 1985, Bankers Trust developed *index currency option notes* or ICONs. These are bonds in which the amount received by the holder at maturity varies with a foreign exchange rate. Two exchange rates, X_1 and, X_2, are specified with $X_1 > X_2$. If the exchange rate at the bond's maturity is above X_1, the bondholder receives the full face value. If it is less than X_2, the bondholder receives nothing. Between X_2 and X_1, a portion of the full face value is received. Bankers Trust's first issue of an ICON was for the Long Term Credit Bank of Japan. The ICON specified that if the yen–U.S. dollar exchange rate, S, is greater than 169 yen per dollar at maturity (in 1995), the holder of the bond receives $1,000. If it is less than 169 yen per dollar, the amount received by holder of the bond is reduced by

$$\max\left[0,\ 1000\left(\frac{169}{S}-1\right)\right]$$

When the exchange rate is below 84.5, nothing is received by the holder at maturity.

Range Forward Contracts

A *range forward contract* (or flexible forward contract) is another interesting example of a derivative security. Suppose that on September 11, 1991, a U.S. company finds that it will require sterling in 90 days' time and faces the exchange rates shown in Table 1.1. It could enter into a 90-day forward contract to buy at $1.7090 per pound. Alternatively, a range forward exchange band could be set from, say, $1.6700 per pound to $1.7500 per pound. At maturity, if the spot rate is less than $1.6700 per pound, the company pays $1.6700 per pound; if it is between $1.6700 and $1.7500, the company pays the spot rate; if it is greater than $1.7500, the company pays $1.7500. Like a regular forward contract, a range forward contract is normally structured so that it is initially worth zero to both parties.

Other Examples

As mentioned earlier, there is virtually no limit to the innovations that are possible in the derivative securities area. Some of the options traded over the counter have payoffs dependent on maximum value attained by a variable during a period of time; some have exercise prices which are functions of time; some

have features where exercising one option automatically gives the holder another option; and so on. Up to now, the variables underlying options and other derivative securities have usually been stock prices, stock indices, interest rates, exchange rates, and commodity prices. However, other variables can be, and on occasion have been, used. For example, ski slope operators have been known to issue bonds where the payoff depends on the total snow falling at a certain resort, and banks have been known to create deposit instruments where the interest paid depends on the performance of the local football team.

1.5 TYPES OF TRADERS

Traders of derivative securities can be categorized as hedgers, speculators, or arbitrageurs. We now take a first look at each each of these.

HEDGERS

Hedgers are interested in reducing a risk that they already face. Suppose that a U.S. company knows that it is due to pay £1,000,000 to one of its British suppliers in 90 days. It is faced with a significant foreign exchange risk. The cost, in U.S. dollars, of making the payment depends on the sterling exchange rate in 90 days. Using the rates quoted in Table 1.1, the company can choose to hedge by entering into a long forward contract to buy £1,000,000 in 90 days for $1,709,000. The effect is to lock in the exchange rate that will apply to the sterling it requires.

This hedge using forward exchange rates requires no initial payment. In some circumstances it saves the company a significant amount of money. For example, if the exchange rate rises to 1.8000, the company ends up $91,000 better off if it hedges. In other circumstances, the company may wish it had not hedged. For example, if the exchange rate falls to 1.6000, hedging leads to an outcome that is $109,000 worse than no hedging. This emphasizes that the purpose of hedging is to make the outcome more certain. It does not necessarily improve the outcome.

As an alternative to a forward contract, the company could buy a call option to acquire £1,000,000 at a certain exchange rate, say 1.7000, in 90 days. If the actual exchange rate in 90 days proves to be above 1.7000, the company exercises the option and buys the sterling it requires for $1,700,000. If the actual exchange rate proves to be below 1.7000, the company buys the sterling in the market in the usual way. This option strategy enables the company to insure itself against adverse exchange rate movements while still benefitting from favorable movements. Of course this insurance is achieved at a cost. Whereas forward contracts require no initial payment, option contracts can be quite expensive.

Speculators

Whereas hedgers want to eliminate an exposure to movements in the price of an asset, speculators wish to take a position in the market. Either they are betting that a price will go up or they are betting that it will go down.

Forward contracts can be used for speculation. An investor who thinks that sterling will increase in value relative to the U.S. dollar can speculate by taking a long position in a forward contract on sterling. Suppose that in the situation depicted in Table 1.1, the actual spot sterling exchange rate in 90 days proves to be 1.7600. An investor who enters into a long position in a 90-day forward contract will be able to purchase pounds for $1.7090 when they are worth $1.7600. He or she will realize a gain of $0.0510 per pound.

There is an important difference between speculating using forward markets and speculating by buying the underlying asset (in this case, a currency) in the spot market. Buying a certain amount of the underlying asset in the spot market requires an initial cash payment equal to the total value of what is bought. Entering into a forward contract on the same amount of the asset requires no initial cash payment.[4] Speculating using forward markets therefore provides an investor with a much higher level of leverage than speculating using spot markets.

Options when used for speculation also give extra leverage. To illustrate this point, suppose that a stock price is $32 and an investor who feels that it will rise buys call options with a strike price of $35 for $0.50 per option. If the price does not go above $35 during the life of the option, the investor will lose $0.50 per option (or 100 percent of the investment). However, if the price rises to $40, the investor will realize a profit of $4.50 per option (or 900 percent of the original investment).

Arbitrageurs

Arbitrageurs are a third important group of participants in derivative securities markets. Arbitrage involves locking in a riskless profit by simultaneously entering into transactions in two or more markets. In later chapters, we will show how arbitrage is sometimes possible when the futures price of an asset gets out of line with its cash price. We will also discuss how arbitrage arguments can be used in option pricing. In this section, we illustrate the concept of arbitrage with a very simple example.

[4] In practice, a financial institution when entering into a forward contract with a speculator may require the speculator to deposit some funds up front. These funds, which usually earn interest, are generally a relatively small proportion of the value of the assets underlying the contract. They serve as a guarantee that the contract will be honored by the speculator.

Consider a stock that is traded in both New York and London. Suppose that the stock price is \$172 in New York and £100 in London at a time when the exchange rate is \$1.7500 per pound. An arbitrageur could simultaneously buy 100 shares of the stock in New York and sell them in London to obtain risk-free profit of

$$100 \times (\$1.75 \times 100 - \$172)$$

or \$300 in the absence of transactions costs. Transactions costs would probably eliminate the profit for a small investor. However, large investment houses face very low transactions costs in both the stock market and the foreign exchange market. They 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 that has just been described cannot last for long. As arbitrageurs buy the stock in New York, the forces of supply and demand will cause the 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 our arguments concerning futures prices and the values of option contracts will be based on the assumption that there are no arbitrage opportunities.

1.6 SUMMARY

One of the interesting developments in financial markets over the last 15 to 20 years has been the growing popularity of derivative securities or contingent claims. In many situations, both hedgers and speculators find it more attractive to trade a derivative security on an asset than to trade the asset itself. Some derivative securities are traded on exchanges. Others are made available to corporate clients by financial institutions or added to new issues of securities by underwriters. There seems to be no shortage of new ideas in this area. Much of this book is concerned with the valuation of derivative securities. The aim is to present a unifying framework within which all derivative securities—not just options or futures—can be valued.

In this chapter, we have taken a first look at forward, futures, and options contracts. A forward or futures contract involves an obligation to buy or sell an asset at a certain time in the future for a certain price. There are two types of 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. Forwards, futures, and options are now traded on a wide range of different assets.

Derivative securities have been very successful innovations in capital markets. Three main types of traders can be identified: hedgers, speculators, and arbitrageurs. Hedgers are in the position where they face risk associated with the price of an asset. They use derivative securities to reduce or eliminate this risk. Speculators wish to bet on future movements in the price of an asset. They use derivative securities to get extra leverage. 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 cash price, they will take offsetting positions in the two markets to lock in a profit.

QUESTIONS AND PROBLEMS

1.1. What is the difference between a long forward position and a short forward 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 forward contract when the forward 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 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 investor gain or lose if the cotton price at the end of the contract is (a) 48.20 cents per pound; and (b) 51.30 cents per pound?

1.5. Suppose that you write a put option contract on 100 IBM shares with a strike price of $120 and an expiration date in 3 months. The current price of IBM stock is $121. 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 3-month call with a strike of $30 costs $2.90. You have $5,800 to invest. Identify two alternative strategies, one involving an investment in the stock and the other involving investment in the option. What are the potential gains and losses from each?

1.7. Suppose you own 5,000 shares 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 4 months?

1.8. A stock, when it is first issued, provides funds for a company. Is the same true of a stock option? Discuss.

1.9. Explain why a forward contract can be used for either speculation or hedging.

1.10. Suppose that a European call option to buy a share for $50 costs $2.50 and is held until maturity. Under what circumstances will the holder of the option make a profit?

Under what circumstances will the option be exercised? Draw a diagram illustrating how the profit from a long position in the option depends on the stock price at maturity of the option.

1.11. Suppose that a European put option to sell a share for \$60 costs \$4.00 and is held until maturity. Under what circumstances will the seller of the option (i.e., the party with the short position) make a profit? Under what circumstances will the option be exercised? Draw a diagram illustrating how the profit from a short position in the option depends on the stock price at maturity of the option.

1.12. An investor writes a September call option with a strike price of \$20. It is now May, 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.

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

1.14. Interest rate caps are described in Section 1.4. Which of the following is more valuable,

(a) a cap which guarantees that the rate of interest paid on a floating-rate loan never goes above 10% or

(b) a cap which guarantees that the average rate of interest paid on a floating-rate loan during its life is below 10%?

Explain your answer.

1.15. Show that the Standard Oil bond described in the Section 1.4 is a combination of a regular bond, a long position in call options on oil with a strike price of \$25, and a short position in call options on oil with a strike price of \$40.

1.16. A company knows it is due to receive a certain amount of a foreign currency in 4 months. What type of option contract is appropriate for hedging?

1.17. The price of gold is currently \$500 per ounce. The futures price for delivery in one year is \$700. An arbitrageur can borrow money at 10% per annum. What should the arbitrageur do? Assume that the cost of storing gold is zero.

1.18. The Chicago Board of Trade offers a futures contract on long-term Treasury bonds. Characterize the investors likely to use this contract.

1.19. The current price of a stock is \$94 and 3-month 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?

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

1.21. Describe the payoff from the following portfolio: a long forward contract on an asset and a long European put option on the asset with the same maturity as the forward contract and a strike price that is equal to the forward price of the asset at the time the portfolio is set up.

1.22. Show that a range forward contract, such as the one described in Section 1.4, is a combination of two options. How can a range forward contract be constructed so that it has zero value?

1.23. Show that an ICON, such as the one described in Section 1.4, is a combination of a regular bond and two options.

1.24. On July 1, 1992, a company enters into a forward contract to buy 10 million Japanese yen on January 1, 1993. On September 1, 1992, it enters into a forward contract to sell 10 million Japanese yen on January 1, 1993. Describe the payoff from this strategy.

1.25. Suppose that sterling–U.S. dollar spot and forward exchange rates are as given in Table 1.1. What opportunities are open to an investor in the following situations?
(a) A 180-day European call option to buy £1 for $1.6700 costs 2 cents.
(b) A 90-day European put option to sell £1 for $1.73 costs 2 cents.

1.26. "A long forward contract is equivalent to a long position in a European call option and a short position in a European put option." Explain this statement.