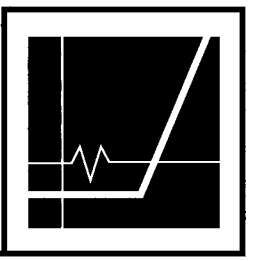

CHAPTER 1

INTRODUCTION

In the last 20 years derivatives have become increasingly important in the world of finance. Futures and options are now traded actively on many exchanges throughout the world. Forward contracts, swaps, and many different types of options are regularly traded outside exchanges by financial institutions, fund managers, and corporate treasurers in what is termed the *over-the-counter* market. Derivatives are also sometimes added to a bond or stock issue.

A *derivative* can be defined as a financial instrument whose value depends on (or derives from) the values of other, more basic underlying variables. Very often the variables underlying derivatives are the prices of traded assets. A stock option, for example, is a derivative whose value is dependent on the price of a stock. However, derivatives can be dependent on almost any variable, from the price of hogs to the amount of snow falling at a certain ski resort.

Since the first edition of this book was published in 1988, there have been many developments in derivatives markets. Many new types of interest rate, foreign exchange, and equity derivative products have been created. There have been many new ideas in risk management and risk measurement. Analysts have also become more aware of the need to analyze what are known as *real options*. (These are the options acquired by a company when it invests in real assets such as real estate, plant, and equipment.) This edition of the book reflects all these developments.

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

1.1 EXCHANGE-TRADED MARKETS

A derivatives exchange is a market where individuals trade standardized contracts that have been defined by the exchange. Derivatives exchanges have existed for a long time. The Chicago Board of Trade (CBOT, www.cbot.com) 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. A rival futures exchange, the Chicago Mercantile Exchange (CME, www.cme.com), was established in 1919. Now futures exchanges exist all over the world.

The Chicago Board Options Exchange (CBOE, www.cboe.com) started trading call option

contracts on 16 stocks in 1973. Options had traded prior to 1973 but the CBOE succeeded in creating an orderly market with well-defined contracts. Put option contracts started trading on the exchange in 1977. The CBOE now trades options on over 1200 stocks and many different stock indices. Like futures, options have proved to be very popular contracts. Many other exchanges throughout the world now trade options. The underlying assets include foreign currencies and futures contracts as well as stocks and stock indices.

Traditionally derivatives traders have met on the floor of an exchange and used shouting and a complicated set of hand signals to indicate the trades they would like to carry out. This is known as the *open outcry system*. In recent years exchanges have increasingly moved from the open outcry system to *electronic trading*. The latter involves traders entering their desired trades at a keyboard and a computer being used to match buyers and sellers. There seems little doubt that eventually all exchanges will use electronic trading.

1.2 OVER-THE-COUNTER MARKETS

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

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

1.3 FORWARD CONTRACTS

A *forward contract* is a particularly simple derivative. It is an agreement to buy or sell an asset at a certain future time for a certain price. It can be contrasted with a *spot contract*, which is an agreement to buy or sell an asset today. A forward contract is traded in the over-the-counter market—usually between two financial institutions or between 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 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.

Forward contracts on foreign exchange are very popular. Most large banks have a "forward desk" within their foreign exchange trading room that is devoted to the trading of forward

Table 1.1 Spot and forward quotes for the USD–GBP exchange rate, August 16, 2001 (GBP = British pound; USD = U.S. dollar)

	Bid	*Offer*
Spot	1.4452	1.4456
1-month forward	1.4435	1.4440
3-month forward	1.4402	1.4407
6-month forward	1.4353	1.4359
1-year forward	1.4262	1.4268

contracts. Table 1.1 provides the quotes on the exchange rate between the British pound (GBP) and the U.S. dollar (USD) that might be made by a large international bank on August 16, 2001. The quote is for the number of USD per GBP. The first quote indicates that the bank is prepared to buy GBP (i.e., sterling) in the spot market (i.e., for virtually immediate delivery) at the rate of $1.4452 per GBP and sell sterling in the spot market at $1.4456 per GBP. The second quote indicates that the bank is prepared to buy sterling in one month at $1.4435 per GBP and sell sterling in one month at $1.4440 per GBP; the third quote indicates that it is prepared to buy sterling in three months at $1.4402 per GBP and sell sterling in three months at $1.4407 per GBP; and so on. These 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 given Table 1.1.)

Forward contracts can be used to hedge foreign currency risk. Suppose that on August 16, 2001, the treasurer of a U.S. corporation knows that the corporation will pay £1 million in six months (on February 16, 2002) and wants to hedge against exchange rate moves. Using the quotes in Table 1.1, the treasurer can agree to buy £1 million six months forward at an exchange rate of 1.4359. The corporation then has a long forward contract on GBP. It has agreed that on February 16, 2002, it will buy £1 million from the bank for $1.4359 million. The bank has a short forward contract on GBP. It has agreed that on February 16, 2002, it will sell £1 million for $1.4359 million. Both sides have made a binding commitment.

Payoffs from Forward Contracts

Consider the position of the corporation in the trade we have just described. What are the possible outcomes? The forward contract obligates the corporation to buy £1 million for $1,435,900. If the spot exchange rate rose to, say, 1.5000, at the end of the six months the forward contract would be worth $64,100 (= $1,500,000 − $1,435,900) to the corporation. It would enable £1 million to be purchased at 1.4359 rather than 1.5000. Similarly, if the spot exchange rate fell to 1.4000 at the end of the six months, the forward contract would have a negative value to the corporation of $35,900 because it would lead to the corporation paying $35,900 more than the market price for the sterling.

In general, 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

$$K - S_T$$

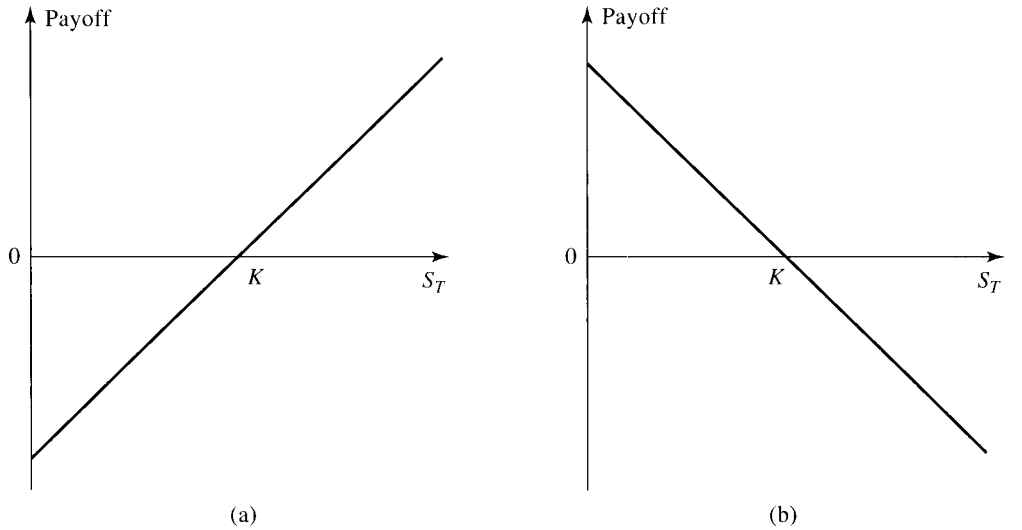

Figure 1.1 Payoffs from forward contracts: (a) long position, (b) short position. Delivery price = K; price of asset at maturity = S_T

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

Forward Price and Delivery Price

It is important to distinguish between the forward price and delivery price. The *forward price* is the market price that would be agreed to today for delivery of the asset at a specified maturity date. The forward price is usually different from the spot price and varies with the maturity date (see Table 1.1).

In the example we considered earlier, the forward price on August 16, 2001, is 1.4359 for a contract maturing on February 16, 2002. The corporation enters into a contract and 1.4359 becomes the delivery price for the contract. As we move through time the delivery price for the corporation's contract does not change, but the forward price for a contract maturing on February 16, 2002, is likely to do so. For example, if GBP strengthens relative to USD in the second half of August the forward price could rise to 1.4500 by September 1, 2001.

Forward Prices and Spot Prices

We will be discussing in some detail the relationship between spot and forward prices in Chapter 3. In this section we illustrate the reason why the two are related by considering forward contracts on gold. We assume that there are no storage costs associated with gold and that gold earns no income.[1]

Suppose that the spot price of gold is \$300 per ounce and the risk-free interest rate for investments lasting one year is 5% per annum. What is a reasonable value for the one-year forward price of gold?

[1] This is not totally realistic. In practice, storage costs are close to zero, but an income of 1 to 2% per annum can be earned by lending gold.

Suppose first that the one-year forward price is $340 per ounce. A trader can immediately take the following actions:

1. Borrow $300 at 5% for one year.
2. Buy one ounce of gold.
3. Enter into a short forward contract to sell the gold for $340 in one year.

The interest on the $300 that is borrowed (assuming annual compounding) is $15. The trader can, therefore, use $315 of the $340 that is obtained for the gold in one year to repay the loan. The remaining $25 is profit. Any one-year forward price greater than $315 will lead to this arbitrage trading strategy being profitable.

Suppose next that the forward price is $300. An investor who has a portfolio that includes gold can

1. Sell the gold for $300 per ounce.
2. Invest the proceeds at 5%.
3. Enter into a long forward contract to repurchase the gold in one year for $300 per ounce.

When this strategy is compared with the alternative strategy of keeping the gold in the portfolio for one year, we see that the investor is better off by $15 per ounce. In any situation where the forward price is less than $315, investors holding gold have an incentive to sell the gold and enter into a long forward contract in the way that has been described.

The first strategy is profitable when the one-year forward price of gold is greater than $315. As more traders attempt to take advantage of this strategy, the demand for short forward contracts will increase and the one-year forward price of gold will fall. The second strategy is profitable for all investors who hold gold in their portfolios when the one-year forward price of gold is less than $315. As these investors attempt to take advantage of this strategy, the demand for long forward contracts will increase and the one-year forward price of gold will rise. Assuming that individuals are always willing to take advantage of arbitrage opportunities when they arise, we can conclude that the activities of traders should cause the one-year forward price of gold to be exactly $315. Any other price leads to an arbitrage opportunity.[2]

1.4 FUTURES CONTRACTS

Like a forward contract, a futures 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 the two parties to the contract do not necessarily know each other, the exchange also provides a mechanism that 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 throughout the world, 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, and Treasury bonds.

[2] Our arguments make the simplifying assumption that the rate of interest on borrowed funds is the same as the rate of interest on invested funds.

One way in which a futures contract is different from a forward contract is that an exact delivery date is usually not 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 entire month. The holder of the short position has the right to choose the time during the delivery period when it 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 and how the futures price is to be quoted. 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 18 months 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 as $300. This is the price, exclusive of commissions, at which traders 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 (i.e., by the laws of supply and demand). If more traders want to go long than to go short, the price goes up; if the reverse is true, the price goes down.[3]

Further details on issues such as margin requirements, daily settlement procedures, delivery procedures, bid–offer spreads, and the role of the exchange clearinghouse are given in Chapter 2.

1.5 OPTIONS

Options are traded both on exchanges and in the over-the-counter market. 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* or *maturity*. *American options* can be exercised at any time up to the expiration date. *European options* can be exercised only on the expiration date itself.[4] Most of the options that are traded on exchanges are American. In the exchange-traded equity options market, one contract is usually an agreement to buy or sell 100 shares. 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 is what 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, there is a cost to acquiring an option.

Call Options

Consider the situation of an investor who buys a European call option with a strike price of $60 to purchase 100 Microsoft shares. Suppose that the current stock price is $58, the expiration date of

[3] In Chapter 3 we discuss the relationship between a futures price and the spot price of the underlying asset (gold, in this case).

[4] 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.

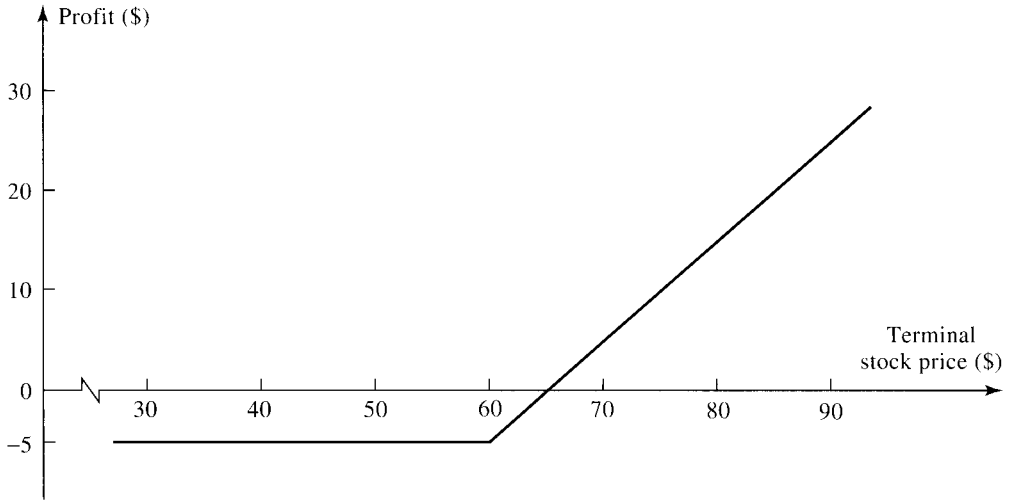

Figure 1.2 Profit from buying a European call option on one Microsoft share. Option price = $5; strike price = $60

the option is in four months, and the price of an option to purchase one share is $5. The initial investment is $500. Because the option is European, the investor can exercise only on the expiration date. If the stock price on this date is less than $60, the investor will clearly choose not to exercise. (There is no point in buying, for $60, a share that has a market value of less than $60.) In these circumstances, the investor loses the whole of the initial investment of $500. If the stock price is above $60 on the expiration date, the option will be exercised. Suppose, for example, that the stock price is $75. By exercising the option, the investor is able to buy 100 shares for $60 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 option is taken into account, the net profit to the investor is $1,000.

Figure 1.2 shows how the investor's net profit or loss on an option to purchase one share varies with the final stock price in the example. (We ignore the time value of money in calculating the profit.) It is important to realize that an investor sometimes exercises an option and makes a loss overall. Suppose that in the example Microsoft's stock price is $62 at the expiration of the option. The investor would exercise the option for a gain of $100 \times (\$62 - \$60) = \$200$ and realize a loss overall of $300 when the initial cost of the option is taken into account. It is tempting to argue that the investor should not exercise the option in these circumstances. However, not exercising would lead to an overall loss of $500, which is worse than the $300 loss when the investor exercises. In general, call options should always be exercised at the expiration date if the stock price is above the strike price.

Put Options

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 a European put option to sell 100 shares in IBM with a strike price of $90. Suppose that the current stock price is $85, the expiration date of the option is in three months, and the price of an option to sell one share is $7. The initial investment is $700. Because the option is European, it will be exercised only if the stock price is below $90 at the expiration date. Suppose that the stock price is $75 on this date. The investor can

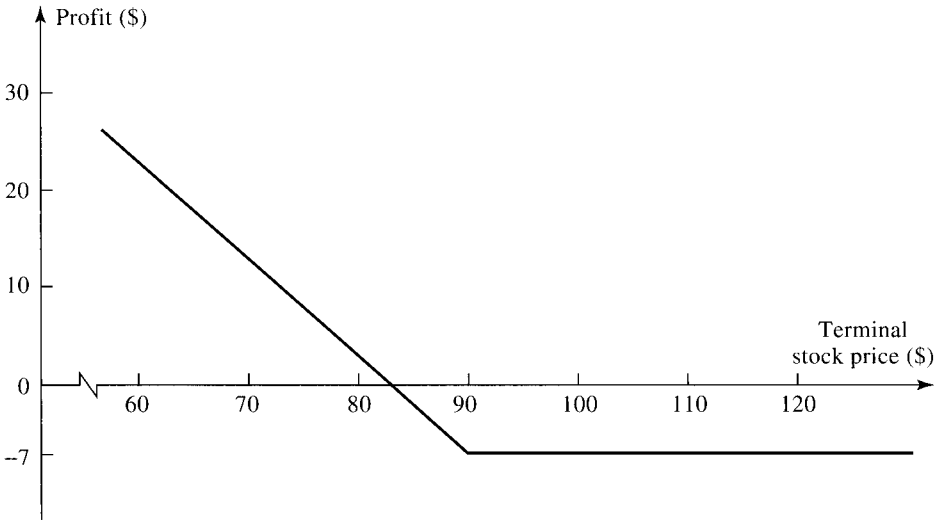

Figure 1.3 Profit from buying a European put option on one IBM share. Option price = $7; strike price = $90

buy 100 shares for $75 per share and, under the terms of the put option, sell the same shares for $90 to realize a gain of $15 per share, or $1,500 (again transactions costs are ignored). When the $700 initial cost of the option is taken into account, the investor's net profit is $800. There is no guarantee that the investor will make a gain. If the final stock price is above $90, the put option expires worthless, and the investor loses $700. Figure 1.3 shows the way in which the investor's profit or loss on an option to sell one share varies with the terminal stock price in this example.

Early Exercise

As already mentioned, exchange-traded stock options are usually American rather than European. That is, the investor in the foregoing examples would not have to wait until the expiration date before exercising the option. We will see in later chapters 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. The writer's 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 or loss with the final stock price for writers of the options considered in Figures 1.2 and 1.3.

There are four types of option positions:

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.

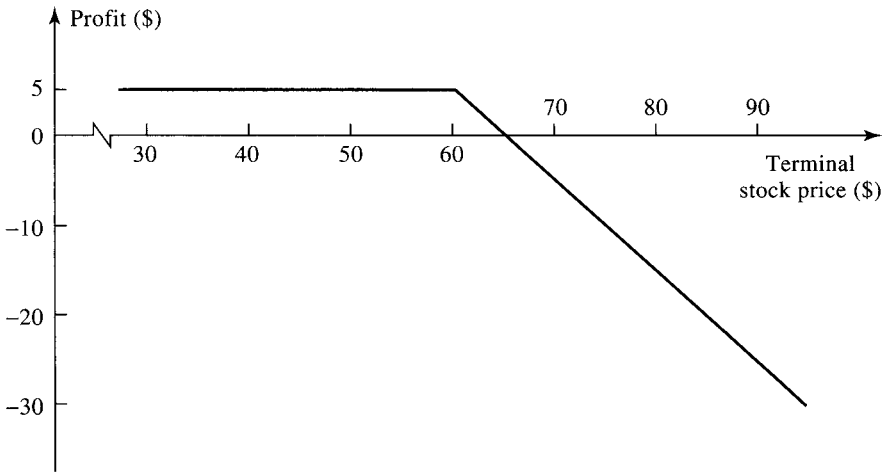

Figure 1.4 Profit from writing a European call option on one Microsoft share. Option price = \$5; strike price = \$60

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

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

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

$$-\max(S_T - K, 0) = \min(K - S_T, 0)$$

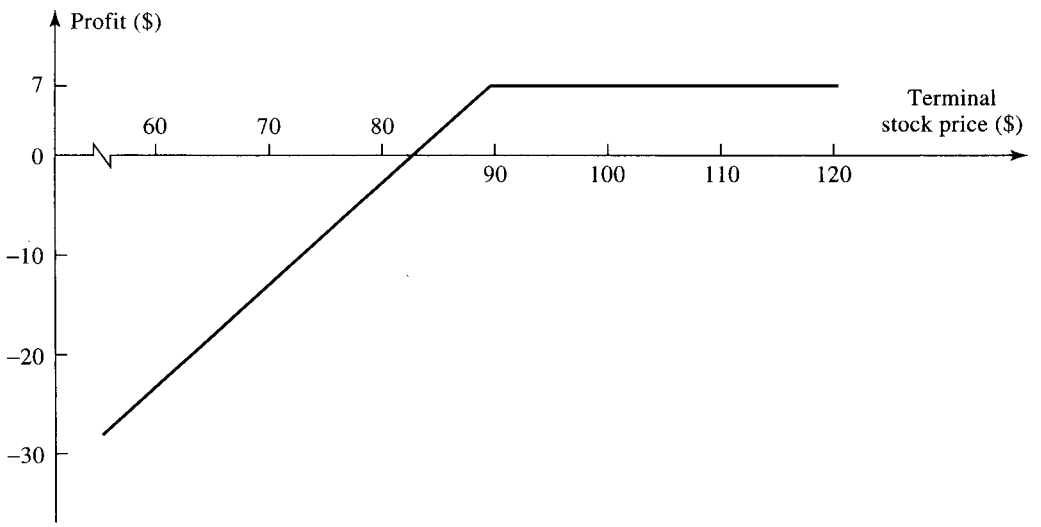

Figure 1.5 Profit from writing a European put option on one IBM share. Option price = \$7; strike price = \$90

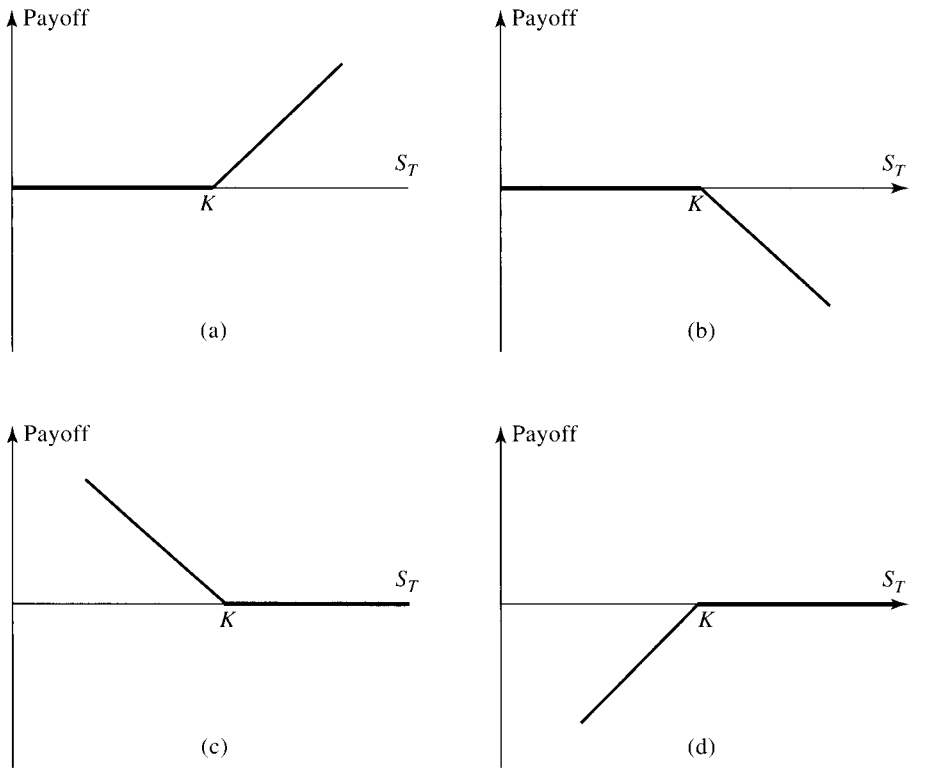

Figure 1.6 Payoffs from positions in European options: (a) long call, (b) short call, (c) long put, (d) short put. Strike price = K; price of asset at maturity = S_T

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

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

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

$$-\max(K - S_T, 0) = \min(S_T - K, 0)$$

Figure 1.6 shows these payoffs.

1.6 TYPES OF TRADERS

Derivatives markets have been outstandingly successful. The main reason is that they have attracted many different types of traders 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 that is prepared to take the other side.

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