PART

1

INSTITUTIONAL BACKGROUND

1 INTRODUCTION TO FUTURES AND OPTIONS

A look at the business pages of the newspaper reveals a bewildering array of price quotations for futures and options. While futures contracts on agricultural commodities have been with us since the mid-1800s, futures trading in financial assets—such as bonds, currencies, and stock indexes—were introduced as recently as 1975 and have grown at an explosive rate since that time. Likewise, trading of options on financial and agricultural commodities is a relatively recent event, dating to the founding of the Chicago Board Options Exchange in April 1973. Today, call options trade on five U.S. exchanges in nearly 400 common stocks. Moreover, options also trade on bonds, foreign currencies, stock indexes, and traditional agricultural commodities.

While futures and options contracts on a variety of underlying commodities[1] have been developed, certain principles of valuation and price behavior are common across all commodities. For example, the essence of the price relation between the futures contract and its underlying commodity is captured by a simple arbitrage argument, even though the types of commodities range from agricultural to purely financial.

In this book, we emphasize the principles that determine the value of a futures contract, an option contract, and a futures option contract relative to the value of its underlying commodity. For example, consider the S&P 500 stock index to be

[1] In this book, the term "commodity" is defined as being something of value. The commodity may be a foodstuff such as wheat, a currency such as the Japanese yen, or a stock index such as the S&P 500.

the underlying commodity. The index is a value-weighted stock portfolio consisting of 500 large common stocks that trade predominantly on the New York Stock Exchange. The Chicago Mercantile Exchange lists a futures contract on the S&P 500, as well as an option contract on the futures, while the Chicago Board Options Exchange lists an option contract on the index itself. In other words, for this particular commodity—the S&P 500 stock index portfolio—the four markets depicted in Figure 1.1 trade simultaneously. Inextricable linkages exist among prices in these four markets, and, in this book, we identify the nature of these price linkages and the implications they have for expected return/risk management. In this chapter, we begin by defining futures, options, and futures options.

1.1 WHAT ARE FUTURES CONTRACTS?

A *futures contract* is a contract to buy or sell an underlying commodity at a future time, at a price—the *futures price*—specified today. Payment for the underlying commodity is not made unless, and until, delivery of the underlying commodity is taken. In organized futures markets, contracts can be reversed before expiration by taking a position of opposite sign but equal magnitude in the same futures contract. Someone who buys futures takes a long position and gains to the extent that the futures price at which that position is reversed (the terminal futures price) is above the initial futures price. Someone who sells futures takes a short position and gains if the terminal futures price is below the initial futures price.

The profit from a long futures position initiated at price F_0 is plotted in Figure 1.2a. For every dollar price rise above F_0, the investor makes one dollar. For every

FIGURE 1.1 Interrelations Between Commodity Market and Markets for the Commodity's Derivative Instruments

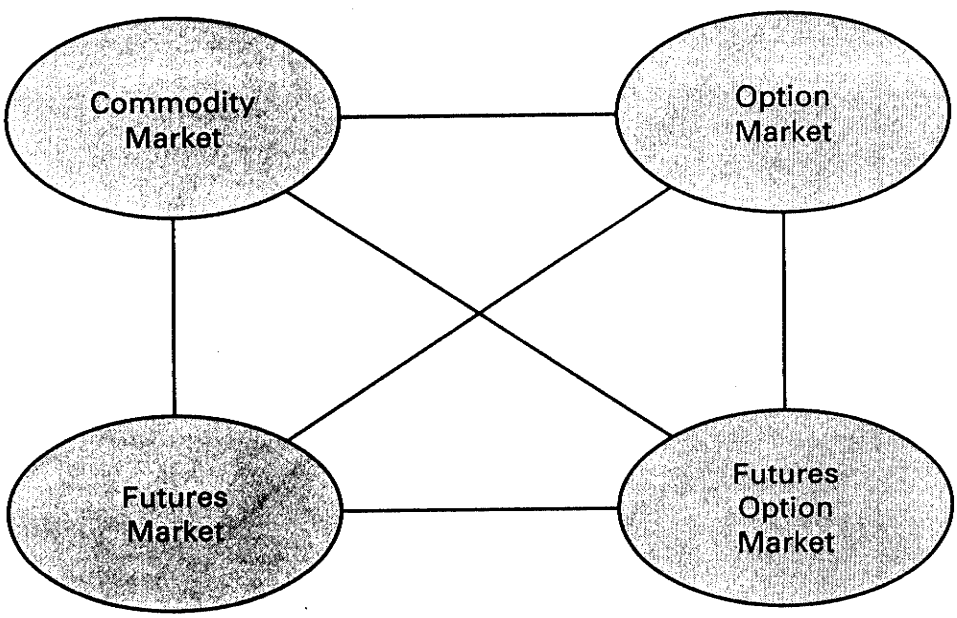
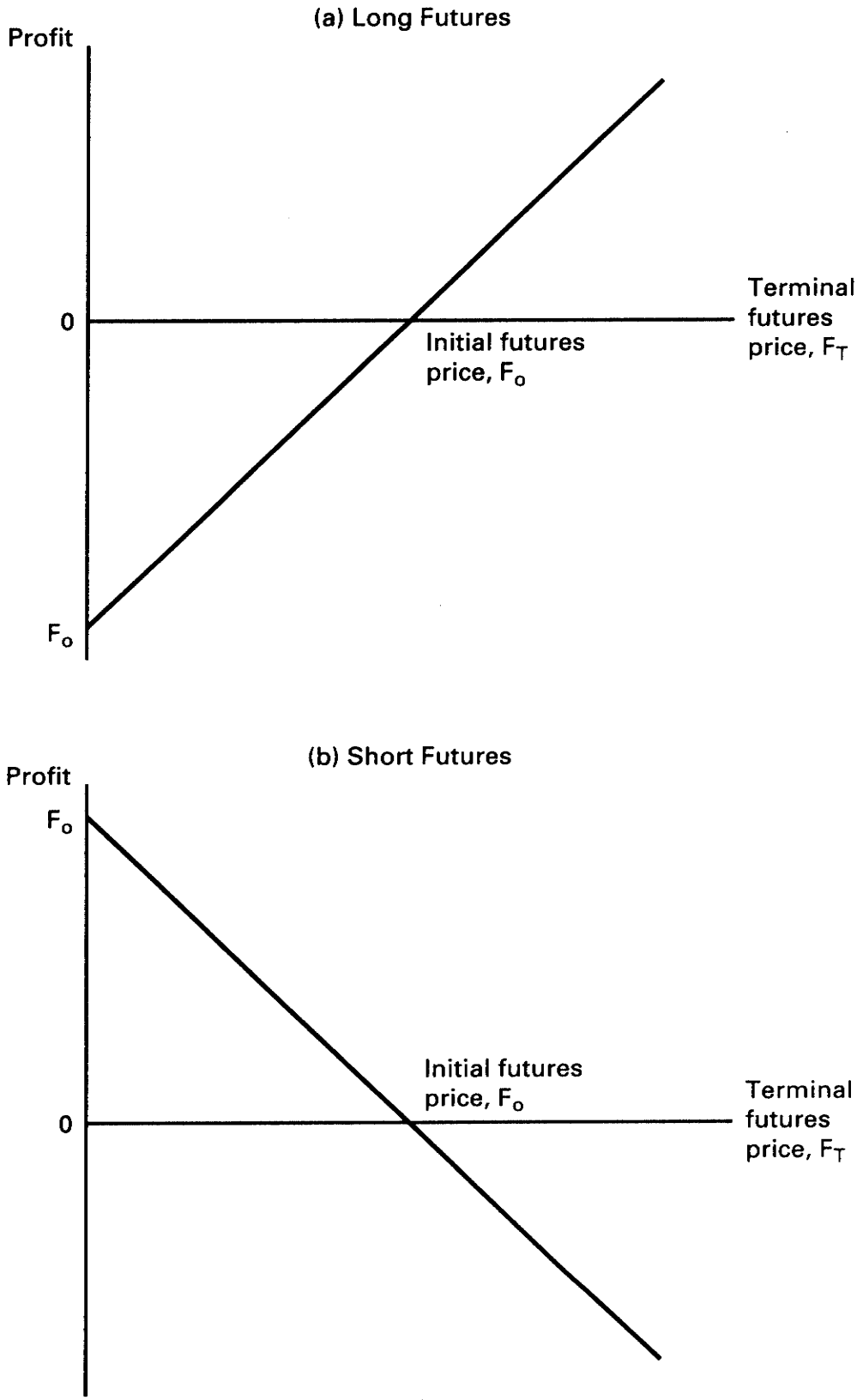


FIGURE 1.2 Profit Diagrams for Futures Position Held to Expiration



dollar decline below F_0, the investor loses one dollar. The profit from a short position initiated at the futures price, F_0, is shown in Figure 1.2b.

As an example, suppose someone buys the July 1992 wheat futures contract listed in Table 1.1. At the close of trading on November 13, 1991, the futures price (F_0) is reported to be \$3.21 per bushel. The denomination of this wheat futures contract is 5,000 bushels. Suppose further that the individual reverses his position on the following February 6 by entering into a contract to sell July wheat. If the price of the July wheat futures (F) is \$4.00 on February 6, the individual earns a profit of (\$4.00 − \$3.21) × 5,000 = \$3,950.00. Alternatively, if the futures price on February 6 is \$3.00, the individual earns a profit of (\$3.00 − \$3.21) × 5,000 = −\$1,050.00. Most futures contracts are, in fact, reversed in this manner prior to expiration.

Futures contracts are a means for reducing risk or assuming risk in the hope of profit, not a means of taking possession of the underlying commodity. Users of the underlying commodity generally prefer a grade and delivery location of the underlying commodity that are different from the grades and locations allowed under the terms of the futures contract.

As a second example, consider the March 1992 S&P 500 index futures reported in Table 1.2. Suppose someone buys this contract at the close of trading on November 13, 1991, at the reported price (F_0) of \$400.35. The contract size for the S&P 500 futures is 500 times the price or \$400.35 × 500 = \$200,175. Suppose the position is reversed on February 6 when the futures price (F) is, say, \$410.00. In this case, the individual earns a profit of (\$410.00 − \$400.35) × 500 = \$4,825.00. If, instead, the index falls to, say, \$390.00, the individual has a loss of (\$400.35 − \$390.00) × 500 = \$5,175.00.

Every futures contract entered into has two sides: a willing buyer and a willing seller. If one side of the contract makes a profit, the other side must make a loss. All futures markets participants taken together can neither lose nor gain—the futures market is a zero-sum game.

TABLE 1.1 Prices of wheat futures contracts at the close of trading on Wednesday, November 13, 1991.

	Open	High	Low	Settle	Change	Lifetime High	Lifetime Low	Open Interest
–GRAINS AND OILSEEDS–								
WHEAT (CBT) 5,000 bu.; cents per bu.								
Dec	347½	352¾	347½	352½	+ 5¼	369¼	272½	19,480
Mr92	349½	353¾	348	353½	+ 5¾	367	279	23,394
May	334	338½	334	338	+ 5¼	352½	280½	5,174
July	317½	321	316¾	321	+ 4¾	337½	279	8,067
Sept	326	326	326	326	+ 5	341	292	690
Dec	333½	335	332	335	+ 4¾	351	329½	703
Est vol 15,500; vol Tues 11,502; open int 57,508, −149.								

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TABLE 1.2 Prices of S&P 500 stock index futures contracts at the close of trading on Wednesday, November 13, 1991.

FUTURES

S&P 500 INDEX (CME) 500 times index

	Open	High	Low	Settle	Chg	High	Low	Open Interest
Dec	395.00	398.50	394.30	398.30	+ 1.00	401.50	316.50	139,341
Mr92	396.80	400.50	396.50	400.35	+ 1.00	404.00	374.70	7,544
June	398.30	402.35	398.30	402.20	+ 1.10	407.00	379.00	1,102

Est vol 42,125; vol Tues 41,413; open int 148,048, +916.
Indx prelim High 397.42; Low 394.01; Close 397.42 +.68

1.2 WHAT ARE OPTIONS?

An *option contract* conveys the right to buy or sell an underlying commodity at a specified price within a specified period of time. The right to buy is referred to as a *call option*; the right to sell is a *put option*. Options are generally described by the nature of the underlying commodity. An option on a common stock is said to be a *stock option*; an option on a bond, a *bond option*; an option on a foreign currency, a *currency option*; an option on a futures contract, a *futures option*; and so on. The specified price at which the underlying commodity may be bought (in the case of a call) or sold (in the case of a put) is called the *exercise price* or the *striking price* of the option. To buy or sell the underlying commodity pursuant to the option contract is to exercise the option. Most options may be exercised at any time, up to and including the expiration date. These are called *American options*. If an option can only be exercised at expiration, it is termed a *European option*.

The buyer of an option pays the option writer (seller) an amount of money called the *option premium* or *option price*. In return, the buyer receives the privilege, but not the obligation, of buying (in the case of a call) or selling (in the case of a put) the underlying commodity for the exercise price. In the case of a call option, if the price of the commodity exceeds the exercise price, the call option is said to be *in-the-money*; and the call option buyer could exercise the option, thereby earning the difference between the two prices—the *exercise value* or *intrinsic value*. On the other hand, if the price of the commodity is below the exercise price, the call option is *out-of-the-money* and will not be exercised. Its intrinsic value is zero. In the case of a put option, if the price of the commodity is below the exercise price, the put option is said to be *in-the-money*. The put option buyer could exercise the option to earn the difference between the exercise price and the price of the commodity. A put option is said to be *out-of-the-money* when the commodity price exceeds the exercise price.

The profits from various option positions held to expiration are plotted in relation to the price of the underlying commodity in Figures 1.3 and 1.4. The illustrations assume that options are held to the expiration date, T. The price of the underlying commodity at the option's expiration is denoted as S_T.

The position of a call buyer—a long call position—is profitable if the price of the underlying commodity, S_T, exceeds the exercise price, X, by more than the initial price of the call option, C_0. This is depicted in Figure 1.3a. On the other hand, if S_T is below X at expiration, the call option is not exercised. The maximum gain to the call buyer is unlimited because the exercise value of the option increases directly with increases in the value of the underlying commodity, which is unlimited in principle. The maximum loss to the option buyer is C_0.

The position of a call seller or call writer—a short call position—is depicted in Figure 1.3b. The position is the reverse image of the long call position. A call seller faces the possibility of large losses if the price of the underlying commodity increases, because, in that case, the call will be exercised, and the call seller will be requested to purchase the underlying commodity at S_T and deliver it to the call buyer at X. The maximum gain to the call seller is C_0. It is evident from Figures 1.3a and 1.3b that the sum of the profits of the call buyer and call seller at any terminal price, S_T, is zero. As in the case of futures markets, the option market is also a zero-sum game.

The position of a put buyer—a long put position—depicted in Figure 1.4a is profitable if the price of the underlying commodity falls below the exercise price by more than P_0, the initial price of the put. If the price exceeds the exercise price at expiration ($S_T > X$), the put is not exercised. The maximum loss to the put buyer is P_0 and the maximum profit is $X - P_0$.

The position of the put seller—the short put position—depicted in Figure 1.4b is the reverse image of the put buyer's position. The put seller has a maximum gain of P_0 and a maximum loss of $X - P_0$.

Option buyers may choose to realize profits by exercising their options as we have just discussed. More frequently, however, option positions are closed out by selling the option. At expiration, an option may be sold for its exercise value. Before expiration, options usually sell for more than their exercise value. As a result, it is usually, but not always, preferable to close out an option position prior to expiration by selling the option rather than by exercising it. The gain or loss on the option is then just the change in the price.

An example using S&P 100 index options will, perhaps, make this discussion more concrete. Table 1.3 contains the closing prices of S&P 100 index options on November 13, 1991. The S&P 100 option contract size is 100 times the index value. The December call with an exercise price of \$370 has a reported price of \$7.375. This means that a call option buyer would pay a premium of \$7.375 $\times$ 100 = \$737.50 for the right to "buy" the S&P 100 stock index at \$370 $\times$ 100 = \$37,000 any time before the expiration date.[2] If the index level rises from \$371.21 on

[2] S&P 100 index options are American-style and expire on the Saturday following the third Friday of the contract month.

FIGURE 1.3 Profit Diagrams for Call Option Positions Held to Expiration

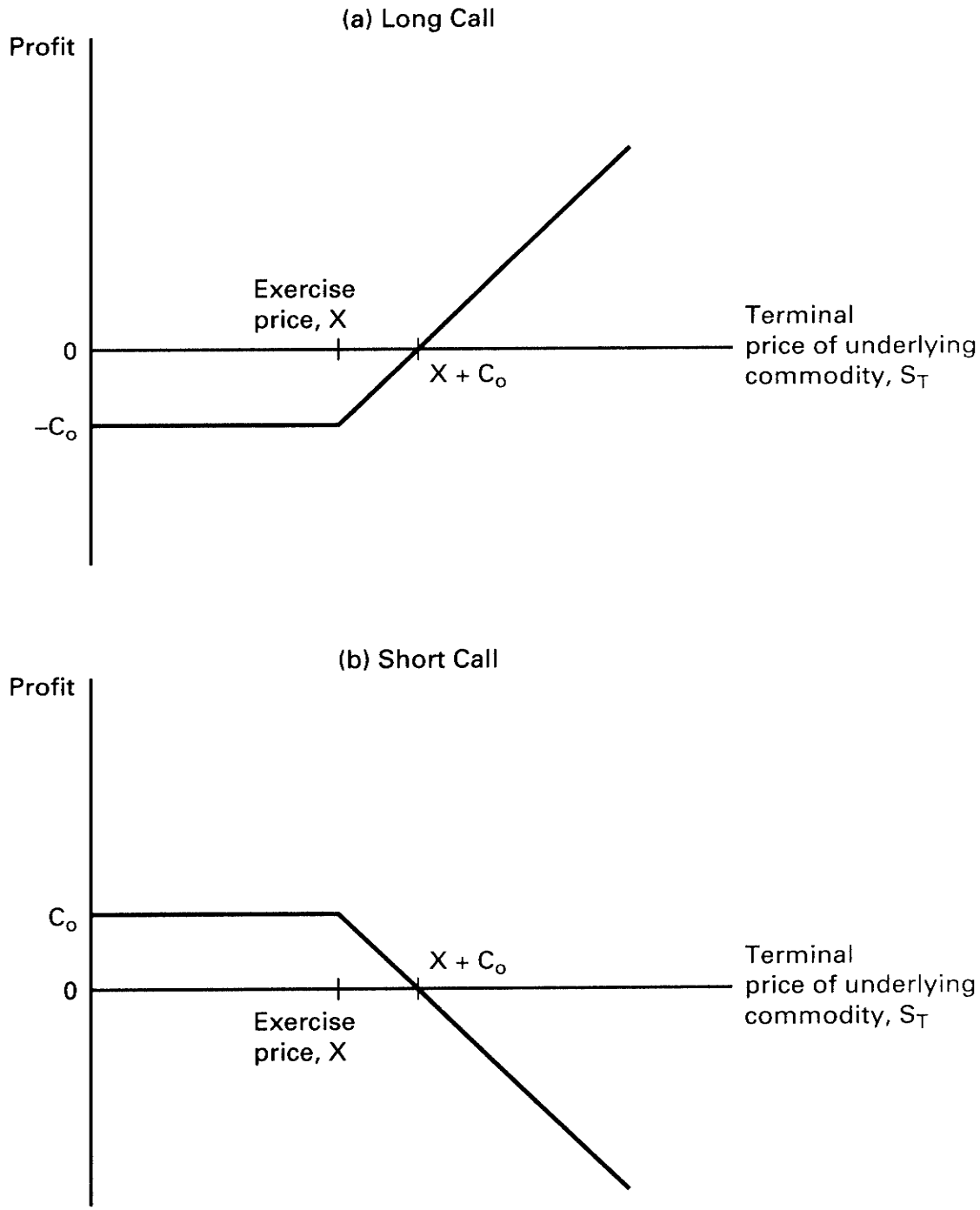

FIGURE 1.4 Profit Diagrams for Put Option Positions Held to Expiration

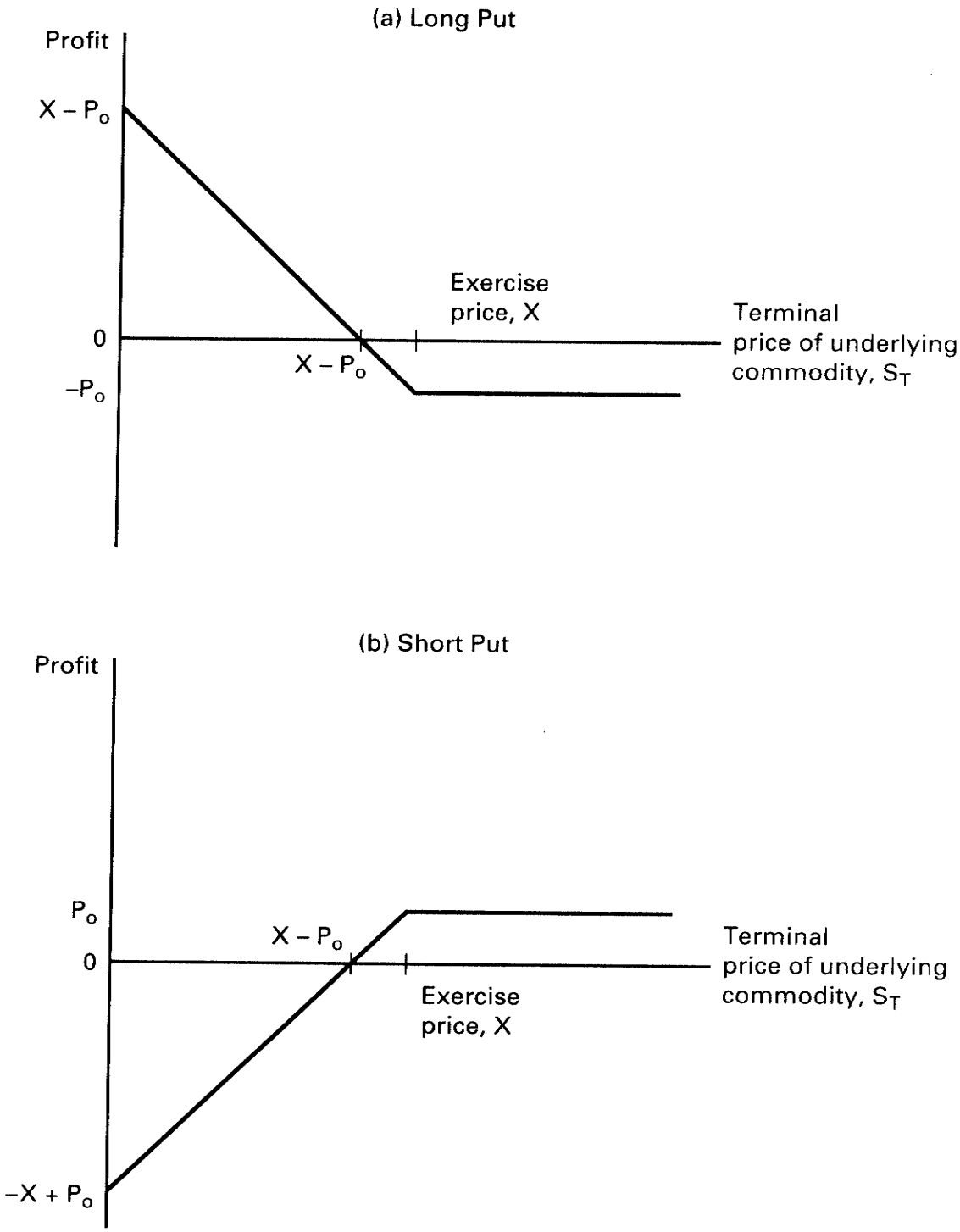

TABLE 1.3 Prices of S&P 100 stock index option contracts at the close of trading on Wednesday, November 13, 1991.

Wednesday, November 13, 1991

OPTIONS

CHICAGO BOARD

S&P 100 INDEX-$100 times index

Strike Price	Calls–Last Nov	Dec	Jan	Puts–Last Nov	Dec	Jan
335	....	....	....	1/16	....	....
340	30	31½	31¼	1/16	⅝	1½
345	23	27	28	1/16	⅞	2⅛
350	21½	21⅛	....	1/16	1 3/16	3
355	16¾	19	19⅝	1/16	1¾	3⅞
360	11¼	14¾	17	⅛	2½	4½
365	6¾	10⅝	13½	5/16	3⅝	6
370	2 5/16	7⅜	10½	1 1/16	5¼	7¾
375	⅜	4⅜	7⅜	4⅛	7⅝	10⅞
380	1/16	2 7/16	5⅛	9¼	10⅞	13¾
385	1/16	1¼	3⅛	....	15¼	....
390	1/16	⅝	1⅞	18⅝	20	20¾

Total call volume 142,982 Total call open int. 387,114
Total put volume 128,390 Total put open int. 421,693
The index: High 371.22; Low 367.54; Close 371.21, +0.92

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November 13 to, say, $400.00 on November 30, the call option buyer can exercise her option to earn a profit of ($400.00 − $370.00 − $7.375) × 100 = $2,262.50. Alternatively, the option buyer can reverse her position by selling an option contract with the same terms. Suppose that on November 30 the price of the call is $32.00. If the buyer of the option on January 16 chooses to sell the same option, she realizes a profit of ($32.00 − $7.375) × 100 = $2,462.50. Note that closing the position by selling the option as opposed to exercising it yields an additional profit of $2,262.50 − $2,462.50 = $200.00.

The fact that the option can be sold for more in the marketplace than the intrinsic value reflects the time value of the option. On November 13, the 370 call can be sold for $7.375 and yet, if that same option is exercised on November 13, its value is $371.21 − $370.00 = $1.21. The difference between the two values is called the time value of the option and reflects the probability that the stock index will rise significantly from its current level by the third Friday in February. The factors affecting the level of option premiums for different striking prices and different maturities are described later in the book.

The price of the 370 December put option in Table 1.3 is reported to be $5.25. This option is out-of-the-money since the current value of the stock index exceeds 370. Someone who buys this put option on November 13 earns a positive profit if the index level falls below $370.00 − $5.25 = $364.75 before the third Friday in December 1992.

It is important to recognize that the option writer (seller) faces payoffs exactly opposite those of the buyer. If, for example, a call option is in-the-money at expiration, the option writer must deliver a commodity worth more than the exercise price received by the writer. In terms of the call option example above, when the buyer of the option chooses to exercise, the option seller in effect has to purchase the index at $400.00 and deliver it to the option buyer at $370.00. This loss is offset in part by the premium, $7.375, that the writer collected at the outset. The net loss to the writer equals the option buyer's net profit. On the other hand, if the index level stays below the exercise price of the call until expiration, the option will not be exercised, and the option writer keeps the premium collected from the buyer when the option contract was written. This time the writer makes a positive profit, but, again, it is equal to the buyer's loss.

1.3 ECONOMIC PURPOSE OF FUTURES AND OPTIONS

Traditional financial instruments such as stocks and bonds are a mechanism for channeling funds from savers to investors as well as a means for spreading risks. (Of course, most trading in stock and bond markets is trading in the secondary market which does not directly allocate new funds to new investment opportunities.) Futures and options facilitate the channeling of funds but are not savings devices. They are primarily a means for dealing with uncertainty. At the same time, they serve to maintain the liquidity and the reliability of underlying commodity prices, which are important for the proper allocation of new investment funds.

The economic benefits of futures and options arise along three dimensions.[3] First, futures and options are a means for allocating risk more efficiently. Second, futures and options provide price information that is useful in allocating resources in the economy to their best uses. Third, futures and options may lower transaction costs of trading in financial markets below the costs associated with trading in existing financial instruments.

Allocation of Risk

Futures and options provide an efficient mechanism for allocating risk from those who wish to avoid risk to those who are interested in bearing the risk. Futures contracts tend to arise when the underlying commodity is costly or cumbersome to trade. For example, futures on agricultural commodities allow an investor to bear the risk associated with holding an agricultural commodity without the troublesome details of trading in the actual commodity. In this manner, processors of the underlying commodity can pass on price risk to investors and retain the economic function of processing the underlying commodity.

Options provide an additional benefit in allocating risk because the profit function for options is different from the profit function for the underlying com-

[3] For an extended discussion of the economic purposes of futures and options, see Carlton (1984), Jaffe (1984), Peck (1985), Silber (1985), and Stoll and Whaley (1988).

modity or for a futures contract. As is evident from Figures 1.3 and 1.4, the profit from options positions are asymmetric. Such an asymmetric payoff pattern is useful, for example, in dealing with situations that involve both quantity and price risk. Consider a farmer who is interested in avoiding the risk associated with a drop in the price of the commodity that he grows. Before the harvest, the farmer does not know the size of the crop or the price. Selling futures against the crop would hedge the farmer against a price decline if the harvest were known, but a futures hedge would expose him to risk if the harvest failed and prices increased, because then the farmer would not have the wheat that he had committed to sell in the futures market. The farmer would take a loss in acquiring the wheat to deliver against the futures contract. Buying a put option on the underlying commodity provides a more effective hedge against price and quantity risk than selling futures. If prices fall, the put is exercised (or liquidated at a profit). If prices rise, the put option expires worthless, and the farmer realizes the revenues from his crop, regardless of the size of the harvest. The cost of this one-sided protection for the farmer is the put option premium. Similar examples exist for other underlying commodities. In addition to this hedging use, options are also a useful portfolio management tool. For example, index put options can be used to limit the down-side risk of stock portfolios while retaining part of the upside potential.

Price Information

Some trading in futures and options markets, as in other financial markets, arises not because individuals have a desire to shift risk, but because they have different information and disagree about the correct price of the underlying commodity. This kind of informational trading is termed *speculative trading*. Society benefits from speculative trading because the analysis and search for information on which it is based cause the prices of futures and options and underlying commodities to correspond more closely to their correct values. Even if an underlying commodity is traded, futures and options on that commodity are likely to increase the interest and the number of judgments bearing on the underlying commodity's price. Because futures and options prices are related to the price of the underlying commodity by an arbitrage relation, factors affecting futures and option prices tend to be conveyed to the price of the underlying commodity; conversely, factors affecting the price of the underlying commodity tend to be conveyed to option and futures prices. Thus, to the extent that futures and option trading increase the total interest in an underlying commodity, the commodity's price will be more broadly based and less likely to be influenced by only a few judgments.

Futures and option markets encourage increased research and analysis. If financial markets are like other markets, this leads to greater efficiency in the production of information. Insofar as increased analysis and increased interest improves the quality of prices, resources will be allocated more efficiently. The price signaling benefit of futures and options is most evident in the case of agricultural futures. For example, the daily newspaper prints futures prices for wheat deliverable many months in the future. That price is the price someone has paid to receive delivery of a particular grade of wheat in the future. Producers or storers of wheat can use this price as a signal for production and storage decisions. If the

price is high relative to their costs, more wheat will be produced and stored. If the price is low relative to their costs, less wheat will produced and stored. In this way, the proper amount of wheat will be allocated for future consumption. Of course, if the futures price is wrong—because it is manipulated or for other reasons—resources will be misallocated. Futures markets depend on the presence of many knowledgeable participants to avoid this. One of the benefits of the introduction of futures is the fact that futures trading increases competition. Producers interested in entering into contracts for delayed delivery are no longer compelled to deal with relatively few users of a commodity.

As we shall see later, option prices depend primarily on the projected volatility of the commodity underlying the option. As a result, option prices quoted in the newspaper provide information on the future price uncertainty of an underlying commodity. Processors and users of the underlying commodity therefore have information not only on the expected price of the underlying commodity but also on the price uncertainty in the future.

Transaction Costs

It is sometimes argued that futures and options are *redundant securities* because any futures or option position is achievable by trading the underlying commodity. For example, a long position in wheat futures has the same profit or loss potential as a long position in the wheat itself. A long position in stock index futures can also be achieved by buying a diversified stock portfolio. The payoff to a Treasury bond futures contract can be replicated by a position in the underlying T-bonds. Similarly, option positions can be replicated by appropriate trading strategies in the underlying commodity.

An important benefit of futures and options, however, is that they reduce transaction costs of achieving certain risk return positions compared with the cost of trading the underlying commodity. It is certainly much less costly to trade wheat futures than to trade wheat itself. But the lower trading cost in futures markets also exists with respect to financial instruments. For example, the transaction costs associated with trading index futures contracts are estimated to be 1/15 of the costs associated with trading the corresponding underlying stocks. Index futures are therefore a less expensive means of trading claims on a portfolio of stocks.

1.4 SUMMARY

In this chapter, payoffs to long and short positions in futures and options are illustrated. The economic purposes of futures and options—risk transfer, price discovery, and reduced transaction costs—are discussed.