CHAPTER 7

Advanced Option Strategies

Read every book by traders to study where they lost money. You will learn nothing relevant from their profits (the markets adjust). You will learn from their losses.

Nassim Taleb
Derivatives Strategy, *April, 1997, p. 25*

CHAPTER OBJECTIVES

- Present and analyze the option spread strategies, including money spreads, collars, calendar spreads, and ratio spreads
- Present and analyze the option combination strategies, including straddles and box spreads

Chapter 6 provided a foundation for the basic option strategies. We can now move on to some of the more advanced strategies. As often noted, options can be combined in some interesting and unusual ways. In this chapter, we look at two types of advanced option strategies: spreads and combinations.

7-1 OPTION SPREADS: BASIC CONCEPTS

A **spread** is the purchase of one option and the sale of another. There are two general types of spreads. One is the **vertical**, **strike**, or **money spread**. This strategy involves the purchase of an option with a particular exercise price and the sale of another option differing only by exercise price. For example, one might purchase an option on DCRB expiring in June with an exercise price of 120 and sell an option on DCRB also expiring in June but with an exercise price of 125; hence the terms *strike* and *money spread*. Because exercise prices were formerly arranged vertically in the option pages of newspapers, this also became known as a *vertical spread*.

Another type of spread is a **horizontal**, **time**, or **calendar spread**. In this spread, the investor purchases an option with an expiration of a given month and sells an otherwise identical option with a different expiration month. For example, one might purchase a DCRB June 120 call and sell a DCRB July 120 call. The term *horizontal spread* comes from the horizontal arrangement of expiration months in newspaper option pages, a practice since discontinued.

Sometimes spreads are identified by a special notation. The aforementioned DCRB money spread is referred to as the June 120/125 spread. The month is given first; the exercise price before the slash (/) is the option purchased, and the exercise price after the slash is the option sold. If the investor buys the June 125 and sells the June 120, the result is a June 125/120 spread. The calendar spread described in the previous paragraph is identified as the June/July 120 spread. The month preceding the slash is the option purchased, whereas the month following the slash identifies the option sold.

Spreads can be executed using either calls or puts. A July 120/125 call spread is a net long position. This is because the 120 call costs more than the 125 call; that is, the cash outflow from buying the 120 exceeds the inflow received for selling the 125. This transaction is called **buying the spread** and is sometimes referred to as a **debit spread** for the type of accounting entry associated with it. In the July 120/125 put spread, the cash inflow received from selling the 125 put is more than the cash outflow paid in buying the 120 put. This transaction is known as **selling the spread** or a **credit spread** and results in a net short position.

For calendar spreads, the June/July 120 call spread would be net short and selling the spread because an investor would receive more for the July call than he or she would pay for the June call. The July/June 120 call spread would be net long and buying the spread because the July call would cost more than the June call. The terms *debit* and *credit spread* are also used here. With calendar spreads, the terminology is similar for both calls and puts because the premiums for both are greater the longer the time to expiration.

7-1a Why Investors Use Option Spreads

Spreads offer the potential for a small profit while limiting the risk. Of course, they are not, of course, the sure route to riches; we already have seen that no such strategy exists. But spreads can be very useful in modifying risk while allowing profits if market forecasts prove accurate.

Risk reduction is achieved by being long in one option and short in another. If the stock price decreases, the loss on a long call will be somewhat offset by a gain on a short call. Whether the gain outweighs the loss depends on the volatility of each call. We shall illustrate this effect later. For now, consider a money spread held to expiration. Assume that we buy the call with the low strike price and sell the call with the high strike price. In a bull market, we will make money because the low-exercise-price call will bring a higher payoff at expiration than will the high-exercise-price call. In a bear market, both calls will probably expire worthless and we will lose money. For that reason, the spread involving the purchase of the low-exercise-price call is referred to as a **bull spread**. Similarly, in a bear market, we make money if we are long the high-exercise-price call and short the low-exercise-price call. This is called a **bear spread**. Opposite rules apply for puts: A position of long (short) the low-exercise-price put and short (long) the high-exercise-price put is a bull (bear) spread. In general, a bull spread should profit in a bull market and a bear spread should profit in a bear market.

Time spreads are not classified into bull and bear spreads. They profit by either increased or decreased volatility. We shall reserve further discussion of time spreads for a later section.

Transaction costs are an important practical consideration in spread trading. These costs can represent a significant portion of invested funds, especially for small traders. Spreads involve several option positions, and the transaction costs can quickly become prohibitive for all but floor traders and large institutional investors. As in Chapter 6, we will not build transaction costs directly into the analyses here but will discuss their special relevance where appropriate.

7-1b Notation

The notation here is the same as that used in previous chapters. We must add some distinguishing symbols, however, for the spreads' different strike prices and expirations. For a money spread, we will use subscripts to distinguish options differing by strike price. For example,

X_1, X_2, X_3 = exercise prices of calls, where $X_1 < X_2 < X_3$
C_1, C_2, C_3 = prices of calls with exercise prices X_1, X_2, X_3
N_1, N_2, N_3 = quantity held of each option.

TABLE 7.1 DCRB OPTION DATA, MAY 14

	CALLS			PUTS		
EXERCISE PRICE	MAY	JUNE	JULY	MAY	JUNE	JULY
120	8.75	15.40	20.90	2.75	9.25	13.65
125	5.75	13.50	18.60	4.60	11.50	16.60
130	3.60	11.35	16.40	7.35	14.25	19.65

Current stock price: 125.94
Expirations: May 21, June 18, July 16
Risk-free rates (continuously compounded): 0.0447 (May); 0.0446 (June); 0.0453 (July)

The N notation indicates the number of options where a positive N is a long position and a negative N is a short position. In time spreads,

T_1, T_2 = time to expiration, where $T_1 < T_2$
C_1, C_2 = prices of calls with times to expiration of T_1, T_2
N_1, N_2 = quantity held of each option.

The numerical illustrations will use the DCRB options presented in earlier chapters. For convenience, Table 7.1 repeats the data. Unless otherwise stated, assume that an option contract for 100 shares of stock is employed.

Your Excel spreadsheet OptionStrategyAnalyzer10e.xlsm can be very useful for analyzing spreads and, indeed, all the transactions in this chapter.

7-2 MONEY SPREADS

As indicated earlier, money spreads can be designed to profit in either a bull or a bear market. The former is called a bull spread.

7-2a Bull Spreads

Consider two call options differing only by exercise price—X_1 and X_2, where $X_1 < X_2$. Their premiums are C_1 and C_2, and we know that $C_1 > C_2$. A bull spread consists of the purchase of the option with the lower exercise price and the sale of the option with the higher exercise price. Assuming one option of each, $N_1 = 1$ and $N_2 = -1$, the profit equation is

$$\Pi = \text{Max}(0, S_T - X_1) - C_1 - \text{Max}(0, S_T - X_2) + C_2.$$

The stock price at expiration can fall into one of three ranges: less than or equal to X_1, greater than X_1 but less than or equal to X_2, or greater than X_2. The profits for these three ranges are as follows:

$$\begin{aligned}
\Pi &= -C_1 + C_2 && \text{if} \quad S_T \leq X_1 < X_2.\\
\Pi &= S_T - X_1 - C_1 + C_2 && \text{if} \quad X_1 < S_T \leq X_2.\\
\Pi &= S_T - X_1 - C_1 - S_T + X_2 + C_2 && \\
&= X_2 - X_1 - C_1 + C_2 && \text{if} \quad X_1 < X_2 < S_T.
\end{aligned}$$

In the case where the stock price ends up equal to or below the lower exercise price, both options expire out-of-the-money. The spreader loses the premium on the long call and retains the premium on the short call. The profit is the same regardless of how far below the lower exercise price the stock price is. Because the premium on the long call is greater than the premium on the short call, however, this profit is actually a loss.

In the third case, where both options end up in-the-money, the short call is exercised on the spreader, who exercises the long call and then delivers the stock. The effect of the stock price cancels and the profit is constant for any stock price above the higher exercise price. Is this profit positive? The profit is $(X_2 - X_1) - (C_1 - C_2)$, or the difference between the exercise prices minus the difference between the premiums. Recall from Chapter 3 that the difference in premiums cannot exceed the difference in exercise prices. The spreader paid a premium of C_1, received a premium of C_2, and thus obtained the spread for a net investment of $C_1 - C_2$. The maximum payoff from the spread is $X_2 - X_1$. No one would pay more than the maximum payoff from an investment. Therefore, the profit is positive.

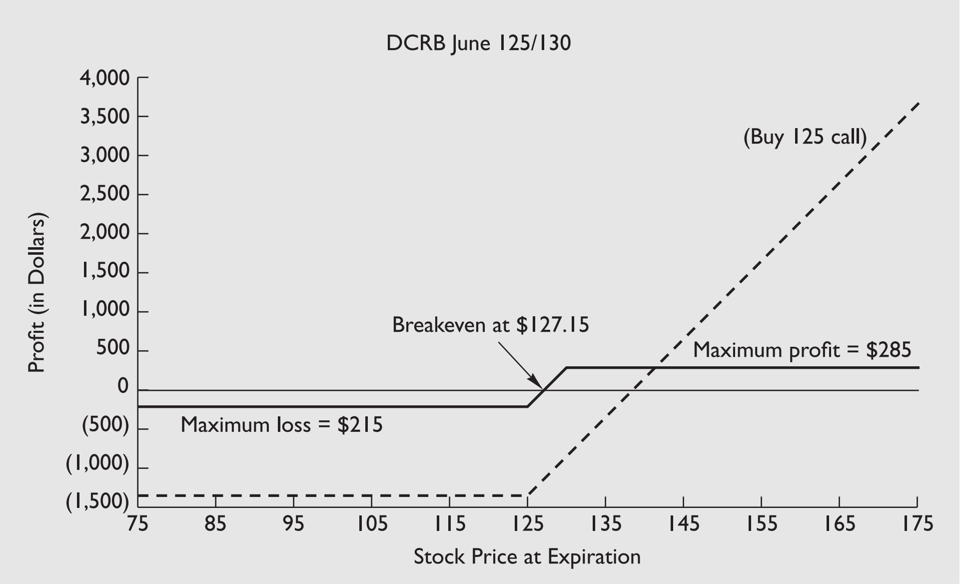
Only in the second case, where the long call ends up in-the-money and the short call is out-of-the-money, is there any uncertainty. The equation shows that the profit increases dollar for dollar with the stock price at expiration.

Figure 7.1 illustrates the profits from the bull spread strategy for the DCRB June 125 and 130 calls with premiums of \$13.50 and \$11.35, respectively. The dashed line is the profit graph had we simply purchased the 125 call. The maximum loss is the net premium of \$1,350 − \$1,135, or \$215, which occurs at any stock price at expiration at or below \$125. The maximum gain is the difference in strike prices minus the difference in premiums, $100(130 - 125 - 2.15) = 285$, which occurs at any stock price at expiration above 130. Note that even though the gain is limited, the maximum is reached at a stock price of 130, which is only 3.2 percent higher than the current stock price. The maximum profit of \$285 is 135 percent of the initial value of the position of \$215. On the downside, however, the maximum loss, 100 percent of the net premium, is reached with only a downward move of 0.7 percent.

A call bull spread has a limited gain, which occurs in a bull market, and a limited loss, which occurs in a bear market.

From the graph, it is apparent that the breakeven stock price at expiration is between the two exercise prices. To find this breakeven—call it

FIGURE 7.1 Call Bull Spread



S_T^*—take the profit equation for the second case, where the stock price is between both exercise prices, and set it equal to zero:

$$\Pi = S_T^* - X_1 - C_1 + C_2 = 0.$$

Then solve for S_T^*:

$$S_T^* = X_1 + C_1 - C_2.$$

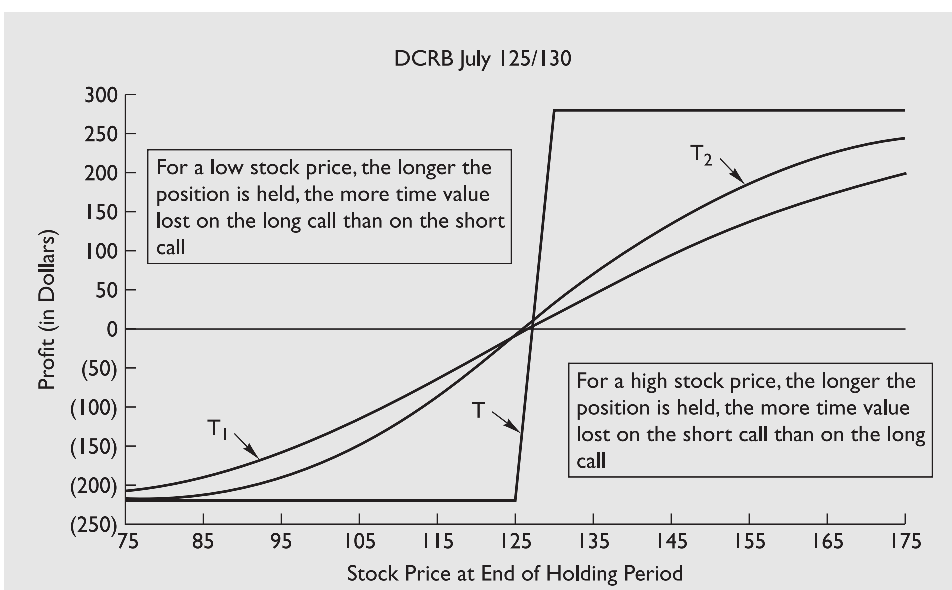
The stock price must exceed the lower exercise price by the difference in the premiums. This makes sense. The spreader exercises the call with exercise price X_1. The higher the stock price, the greater the amount received from the exercise. To break even, the spreader must receive enough to recover the net premium, $C_1 - C_2$. In this problem, the breakeven stock price at expiration is $125 + 13.50 - 11.35 = 127.15$, which is about 1 percent higher than the original stock price.

Note that in comparison to simply buying the 125 call, as indicated by the dashed line, the spreader reduces the maximum loss by the premium on the short 130 call and lowers the breakeven but gives up the chance for large gains if the stock moves up substantially.

Early exercise poses no problem with the bull spread. Suppose that the stock price prior to expiration is S_t. If the short call is exercised, the stock price must be greater than X_2. This means that the stock price is also greater than X_1, and the long call can be exercised for a net payoff of $(S_T - X_1) - (S_T - X_2) = X_2 - X_1$. This is the best outcome one could obtain by holding the spread all the way to expiration.

Choice of Holding Period As with any option strategy, it is possible to hold the position for a period shorter than the option's entire life. Recall that in Chapter 6, we made assumptions about closing out the option positions prior to expiration. We used short holding periods of T_1, which meant closing the position on June 4, and T_2, in which we closed the position on June 25. When a position is closed prior to expiration, we estimate the option price for a range of stock prices and use those estimates to generate the profit graph. We illustrated the general procedure in Chapter 6. Using the same methodology here, we obtain the graph in Figure 7.2, the bull spread under the assumption of three different holding periods.

FIGURE 7.2 Call Bull Spread: Different Holding Periods



For a given stock price, the profit of a call bull spread increases as expiration approaches if the stock price is on the high side and decreases if the stock price is on the low side.

Recall that T_1 is the shortest holding period, T_2 is slightly longer, and T represents holding all the way to expiration. The graph indicates that the short holding period has the lowest range of profits. If the stock price is low, the shortest holding period produces the smallest loss and the longest holding period produces the largest loss. If the stock price is high, the shortest holding period produces the smallest gain and the longest holding period produces the largest gain.

The logic behind these results is simple. First, recall that the low-exercise-price call will always be worth more than the high-exercise-price call; however, their relative time values will differ. An option's time value is greatest when the stock price is near the exercise price. Therefore, when stock prices are high, the high-exercise-price call will have the greater time value, and when they are low, the low-exercise-price call will have the greater time value.

When we close out the spread prior to expiration, we can always expect the long call to sell for more than the short call because the long call has the lower exercise price. The excess of the long call's price over the short call's price will, however, decrease at high stock prices. This is because the time value will be greater on the short call because the stock price is closer to the exercise price. The long call will still sell for a higher price because it has more intrinsic value, but the difference will be smaller at high stock prices. Conversely, at low stock prices, the long call will have a greater time value because its exercise price is closer to the stock price.

MAKING THE CONNECTION

Spreads and Option Margin Requirements

Many option strategies are inherently risky, and option traders face the risk of default from their trading counterparts. Exchange-traded options have the significant advantage of an intermediary that manages credit risk, typically some sort of clearinghouse. In return for the mitigation of counterparty credit risk, clearinghouses require option traders to post margin requirements.

In the past, the margin requirements were based on the specific strategy followed by the trader. For complex positions where many risks are offset, the strategy-based margin requirement would remain very high. Now clearinghouses take a portfolio approach and seek to measure market risk exposures based on the cumulative portfolio risk exposure. The net effect is that option margin positions are considerably lower than in the past.

For example, the margin requirements for a protective put strategy (long stock and long put) could result in a decrease in the margin requirements dramatically. The strategy-based approach would calculate margin based on the 50 percent margin requirement for holding common stock and the 100 percent margin requirement for purchasing puts. We know, however, that protective put buying sets a floor on the portfolio's losses; hence, the portfolio-based approach margin requirement would be dramatically lower. In other words, viewed separately, individual risks of these two positions are quite large, but they have an offsetting, or hedging, element that lowers their combined risks. Fortunately, margin requirements take the combined risk into account.

As we consider numerous other complex option strategies, such as spreads, collars, and other complex combinations, it is important to know that there are margin implications for the trader. An example of the new portfolio margin requirements can be found on the Chicago Board of Options Exchange website (currently www.cboe.com/Margin).

With the combination of lower margin requirements for complex option positions along with an understanding that a call option can be viewed as a leveraged position in stock, the option trader can achieve an extremely high degree of implied leverage in a trading position. Although leverage is beneficial if the position moves in your favor, it can prove disastrous if the position moves against you.

The result of all this is that when we close the bull spread well before expiration, the profit will be lower at high stock prices and higher at low stock prices than if we did so closer to expiration. If we hold the position longer, but not all the way to expiration, we will obtain the same effect, but the impact will be smaller because the time value will be less.

Which holding period should an investor choose? There is no consistently right or wrong answer. An investor who is strongly bullish should realize that the longer the position is held, the greater the profit that can be made if the forecast is correct. In addition, a long holding period allows more time for the stock price to move upward. If the forecast proves incorrect, the loss will be lower the shorter the holding period. With short holding periods, however, there is less time for a large stock price change.

The following section examines a put bear spread. We shall see that a bear spread is, in many respects, the opposite of a bull spread.

7-2b Bear Spreads

A bear spread is the mirror image of a bull spread: The trader is long the high-exercise-price put and short the low-exercise-price put. Since $N_1 = -1$ and $N_2 = +1$, the profit equation is

$$\Pi = -\text{Max}(0, X_1 - S_T) + P_1 + \text{Max}(0, X_2 - S_T) - P_2.$$

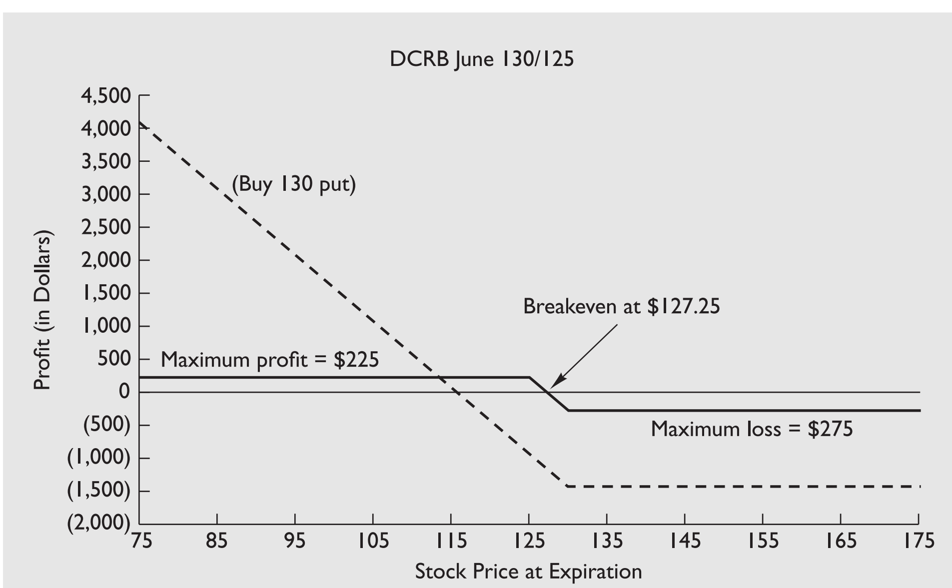
The outcomes are as follows:

$$\begin{aligned} \Pi &= -X_1 + S_T + P_1 + X_2 - S_T - P_2 && \text{if} \quad S_T \le X_1 < X_2. \\ &= X_2 - X_1 + P_1 - P_2 && \\ \Pi &= P_1 + X_2 - S_T - P_2 && \text{if} \quad X_1 < S_T < X_2. \\ \Pi &= P_1 - P_2 && \text{if} \quad X_1 < X_2 \le S_T. \end{aligned}$$

A put bear spread has a limited gain, which occurs in a bear market, and a limited loss, which occurs in a bull market.

Figure 7.3 illustrates the put bear spread for the DCRB June 125 and 130 puts with premiums of \$11.50 and \$14.25, respectively. The dashed line is a long position in the 130 put. The maximum gain is the difference in the strike prices minus the difference in the premiums,

FIGURE 7.3 Put Bear Spread



$100(130 - 125 + 11.50 - 14.25) = 225$, which occurs at any stock price at expiration below 125. The maximum loss is the net premium of \$1,425 − \$1,150 = \$275, which occurs at any stock price at expiration above 130.

As with the call bull spread, the breakeven stock price at expiration is between the two exercise prices. To find this breakeven, S_T, take the profit equation for the second case, where the stock price is between both exercise prices, and set it equal to zero:

$$\Pi = P_1 + X_2 - S_T^* - P_2 = 0.$$

Then solve for

$$S_T^* = P_1 + X_2 - P_2.$$

Here the breakeven stock price is \$130 + \$11.50 − \$14.25 = \$127.25.

Note that the maximum gain is a return of almost 82 percent on an investment of \$275 and requires a downward move of only about 1 percent (from 125.94 to 125). This would seem to make the bear spread an exceptionally tempting strategy. But note also that a slight upward move of just a little more than 1 percent would put the stock past the break-even and generate a loss. An upward move of only about 3.2 percent would take the stock to the upper exercise price, and the entire investment of \$275 would be lost.

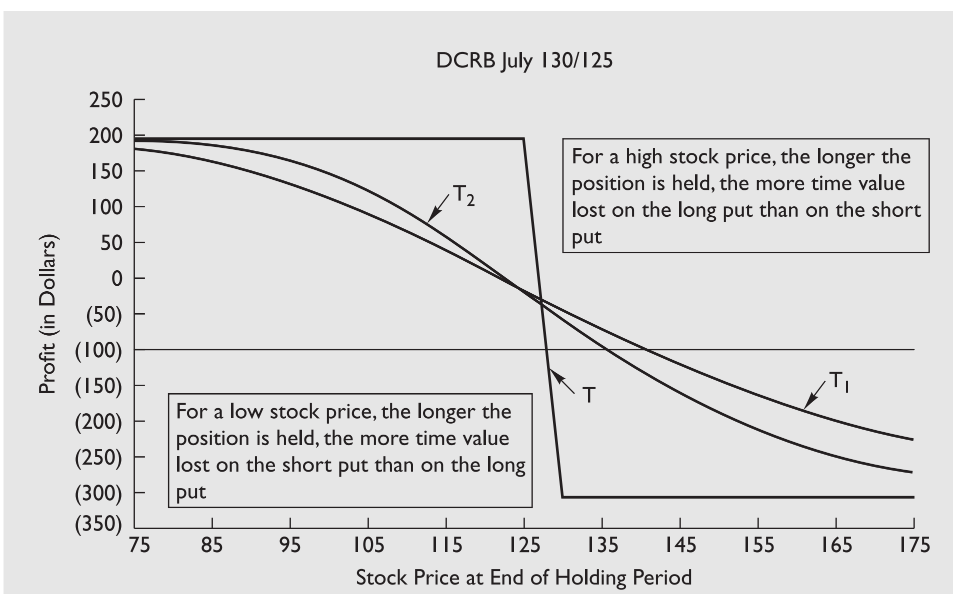
Relative to the long put, as shown by the dashed line, the bear spread has a lower maximum profit (which is limited to \$225), a higher breakeven, and a lower loss on the upside by the amount of the premium from the written put.

Early exercise is not an issue for the put bear spread. This is because the put bear spread will have the long put in-the-money whenever the short put is in-the-money. If the short put is exercised, the long put can be exercised for an overall cash flow of $X_2 - X_1$, which is the maximum payoff obtainable if held to expiration.

> For a given stock price, the profit of a put bear spread increases as expiration approaches if the stock price is on the low side and decreases if the stock price is on the high side.

Choice of Holding Period Figure 7.4 illustrates a bear spread when different holding periods are used. The longer holding period produces

FIGURE 7.4 Put Bear Spread: Different Holding Periods



higher profits in a bear market and larger losses in a bull market. Again, this is because of the time value effect. The spread trader closing the position prior to expiration buys back the time value of the short put and sells the long put's remaining time value. For high stock prices, the long put has more time value than the short put; thus, our long position loses faster than our short position. As time goes by, we lose from this effect. At low stock prices, the short put has more time value than our long put; thus, our short position loses faster than our long position. As time goes by, we gain from this effect.

We should repeat, however, that these statements do not advocate a short or long holding period because the length of the holding period affects the range of possible stock prices.

7-2c A Note about Call Bear Spreads and Put Bull Spreads

As we have seen, it is possible to design a call money spread that will profit in a bull market. It is also possible to construct a call money spread that will profit in a bear market. There is, however, a risk of early exercise. The short call can be sufficiently in-the-money to justify early exercise, whereas the long call is still out-of-the-money. Even if the long call is in-the-money, the cash flow from early exercise will be negative.

Suppose that S_t is the stock price prior to expiration. The cash flow from the exercise of the short call is $-(S_t - X_1)$, whereas the cash flow from the exercise of the long call is $S_t - X_2$. This gives a total cash flow of $X_1 - X_2$, which is negative. Early exercise ensures that the bear spreader will incur a cash outflow. Because the loss occurs prior to expiration, it is greater in present value terms than if it had occurred at expiration. Thus, the call bear spread entails a risk not associated with the bull spread.

Just as we can construct bear money spreads with calls, we can also construct bull money spreads with puts. Here we would buy the low exercise price put and sell the high exercise price put. The pattern of payoffs would be similar to those of the call bull money spread, but as with call bear money spreads, early exercise would pose a risk.

7-2d Collars

Now we shall look at a popular strategy often used by professional money managers that is referred to as a **collar**. A collar is very similar to a bull spread. In fact, the relationship between the two can be seen by applying what we learned about put–call parity.

Suppose that you buy a stock. You wish to protect it against a loss but participate in any gains. An obvious strategy is one we covered in Chapter 6, the protective put. If you buy the put, you will have to pay out cash for the price of the put. The collar reduces the cost of the put by adding a short position in a call, where the exercise price is higher than the exercise price of the put. Although a call with any exercise price can be chosen, there is in fact one particular call that tends to be preferred: the one whose price is the same as that of the put you are buying.

Thus, let us buy the stock and buy a put with an exercise price of X_1 at a price of P_1. Now let us sell a call at an exercise price of X_2 with a premium of C_2. With $N_P = 1$ and $N_C = -1$, the profit equation is

$$\Pi = S_T - S_0 + \text{Max}(0, X_1 - S_T) - P_1 - \text{Max}(0, S_T - X_2) + C_2.$$

The profits for the three ranges are as follows:

$$\begin{aligned}
\Pi &= S_T - S_0 + X_1 - S_T - P_1 + C_2 && \text{if} \quad S_T \le X_1 < X_2. \\
&= X_1 - S_0 - P_1 + C_2 \\
\Pi &= S_T - S_0 - P_1 + C_2 && \text{if} \quad X_1 < S_T < X_2. \\
\Pi &= S_T - S_0 - P_1 - S_T + X_2 + C_2 && \text{if} \quad X_1 < X_2 \le S_T. \\
&= X_2 - S_0 - P_1 + C_2
\end{aligned}$$

Because X_1 is below the current stock price, S_0, and X_2 is above it, the profit on the stock is either $X_1 - S_0$, which is negative, when S_T is at X_1 or below or $X_2 - S_0$, which is positive, when S_T is at X_2 or above. Thus, the potential loss and gain on the stock are fixed and limited. Only in the middle range, where S_T is essentially between the two exercise prices, is there any uncertainty. As noted earlier, it is common to set X_2 such that $C_2 = P_1$, so these terms drop out of the aforementioned profit equations. It is not necessary, however, that we choose the call such that its price offsets the price paid for the put. In such a case, we must add $-P_1 + C_2$ to the stock profit, as indicated in the foregoing equations.

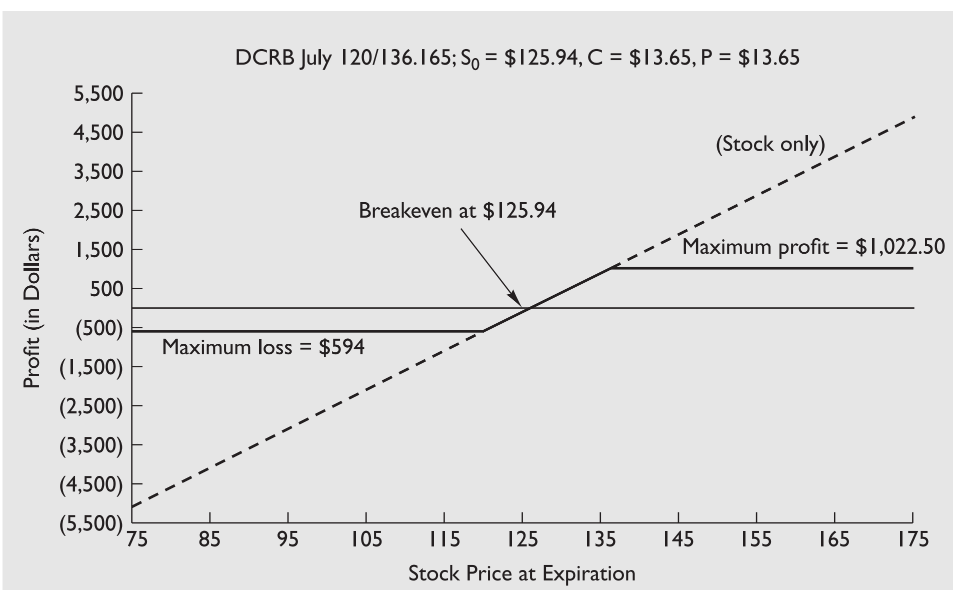
When the call and put premiums do offset each other, the collar is sometimes referred to as a zero-cost collar, but this term is somewhat misleading. Although there is no cash outlay for the options, the cost is in the willingness to give up all gains beyond X_2. In other words, the investor will be selling the stock at a maximum price of X_2, in exchange for which the investor receives the assurance that the stock will be sold for no worse than X_1.

A collar is a strategy in which the holder of a position in a stock buys a put with an exercise price lower than the current stock price and sells a call with an exercise price higher than the current stock price. The call premium is intended to reduce the cost of the put premium. The call exercise price is often set to make the call premium completely offset the put premium.

Although collars are normally used with index options in conjunction with diversified portfolios, we shall stay with the example here of the single stock, DCRB. Figure 7.5 illustrates the collar for the DCRB July 120/136.165. The stock is bought at 125.94. Let us say that we buy the put with an exercise price of 120, which costs 13.65. Now, we need to sell a call with an exercise price such that its premium is 13.65. For the July options, we see that none of the calls have a price of 13.65. The 130 has a price of 16.40, so we will need a call with an exercise price greater than \$130. We can use the Black–Scholes–Merton model to figure out what the exercise price should be. We use the following inputs: $S_0 = 125.94$, $X = 136.165$, $r_c = 0.0453$, $\sigma = 0.83$, and $T = 0.1726$. We find that this call has a Black–Scholes–Merton price of 13.65.

Now we are faced with a problem we have not yet seen. If we use exchange-listed options, we cannot normally designate the exercise price, for this is set by the exchange. We could sell the 135 or the 140, but there is no 136.165. We have two choices. We can use an over-the-counter option, as discussed in Chapter 2, which can be customized to any exercise price. We go to an options dealer and request this specific

FIGURE 7.5 Collar



option. Alternatively, if we trade in sufficient volume, we can use FLEX options, also mentioned in Chapter 2, which trade on the exchanges and permit us to set the exercise price. Let us assume that we do one or the other. For illustrative purposes, it does not matter.

Thus, we buy the 120 put for \$13.65 and sell the 136.165 call for \$13.65. We do 100 of each and buy 100 shares of the DCRB stock. Note that the maximum profit is capped at $100(X_2 - S_0) = 100(136.165 - 125.94) = 1{,}022.50$ and that the maximum loss is $100(S_0 - X_1) = 100(125.94 - 120) = 594$. The breakeven is found by setting the middle equation to zero:

$$\Pi = S_T^* - S_0 = 0,$$

which we see is obviously

$$S_T^* = S_0,$$

and in our problem, $S_T^* = 125.94$, the original stock price. Note in Figure 7.5 that the line for the stock profit passes right through the middle range of profit for the collar. So the investor effectively buys the stock and establishes a maximum loss of \$594 and a maximum gain of \$1,022.50. Note that the maximum profit is earned with an upward move of about 8.1 percent. The maximum loss is incurred with a downward move of about 4.7 percent.

This strategy looks a lot like a bull spread. Let us examine the difference. For the three ranges of S_T, the following are profit equations for the bull spread and collar. For the collar, we substitute from put–call parity, $C_1 - S_0 + X_1(1+r)^{-T}$ for P_1.

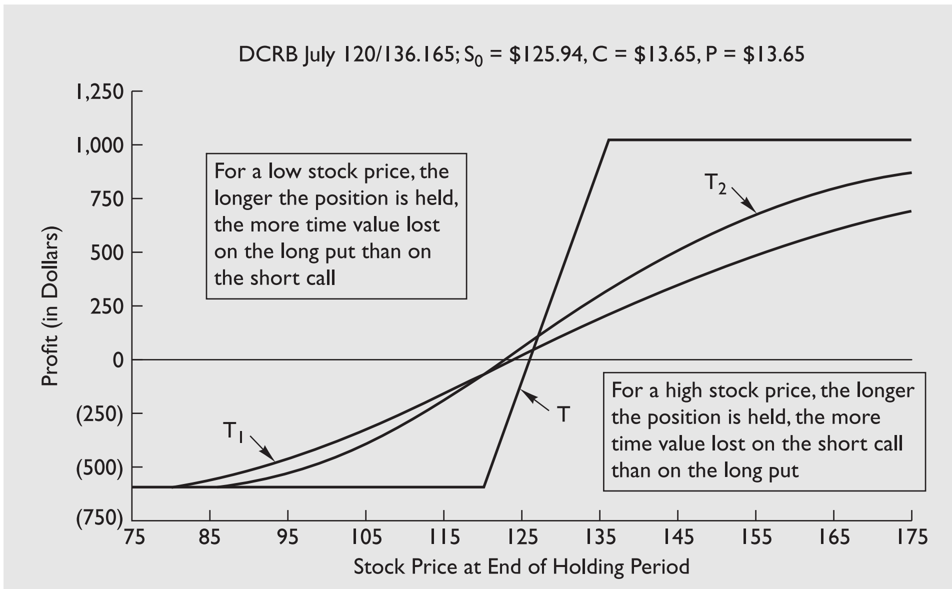
$S_T \le X_1 < X_2$	
Bull spread:	$-C_1 + C_2$
Collar:	$X_1 - S_0 - P_1 + C_2$ $= X_1 - X_1(1+r)^{-T} - C_1 + C_2$
$X_1 < S_T < X_2$	
Bull spread:	$S_T - X_1 - C_1 + C_2$
Collar:	$S_T - S_0 - P_1 + C_2$ $= S_T - X_1(1+r)^{-T} - C_1 + C_2$
$X_1 < X_2 \le S_T$	
Bull spread:	$X_2 - X_1 - C_1 + C_2$
Collar:	$X_2 - S_0 - P_1 + C_2$ $= X_2 - X_1(1+r)^{-T} - C_1 + C_2$

Thus, in all cases, the collar is more profitable by the difference between X_1 and the present value of X_1.

Thus, the bull spread and the collar are similar but not identical. Note that the range of profits for the bull spread is $X_2 - X_1 - C_1 + C_2 - (-C_1 + C_2) = X_2 - X_1$. The range of profits for the collar is $X_2 - X_1(1+r)^{-T} - C_1 + C_2 - [X_1 - X_1(1+r)^{-T} - C_1 + C_2] = X_2 - X_1$. So the two strategies have the same range of profits. The initial outlay for the bull spread is $C_1 - C_2$. The initial outlay for the collar is $S_0 + P_1 - C_2$. Substituting from put–call parity for P_1, this is $X_1(1+r)^{-T} + C_1 - C_2$. The collar is equivalent to a bull spread plus a risk-free bond paying X_1 at expiration.

Choice of Holding Period In Figure 7.6, we see what the profit would look like if the position were closed early. On the downside, by closing the position at T_1, we recoup more

FIGURE 7.6 Collar: Different Holding Periods



of the time value on the long put than we pay to buy back the short call. The longer we hold the position on the downside, the less this works to our advantage. On the upside, if we close the position early, the more time value we must buy back on the short call than we receive from selling the long put. The longer we hold the position, the more this works to our advantage. Remember that these statements are true because the time value is greater where the stock price is close to the exercise price. On the downside, the time value is greater on the long put; on the upside, the time value is greater on the short call.

7-2e Butterfly Spreads

A **butterfly spread**, sometimes called a **sandwich spread**, is a combination of a bull spread and a bear spread. This transaction, however, involves three exercise prices: X_1, X_2, and X_3, where X_2 is halfway between X_1 and X_3. Suppose we construct a call bull spread by purchasing the call with the low exercise price, X_1, and writing the call with the middle exercise price, X_2. Then we also construct a call bear spread by purchasing the call with the high exercise price, X_3, and writing the call with the middle exercise price, X_2. Combining these positions shows that we are long one each of the low- and high-exercise-price options and short two middle-exercise-price options. Because $N_1 = 1$, $N_2 = -2$, and $N_3 = 1$, the profit equation is

$$\Pi = \text{Max}(0, S_T - X_1) - C_1 - 2\text{Max}(0, S_T - X_2) + 2C_2 + \text{Max}(0, S_T - X_3) - C_3.$$

To analyze the behavior of the profit equation, we must examine four ranges of the stock price at expiration:

$$\Pi = -C_1 + 2C_2 - C_3 \qquad \text{if } S_T \leq X_1 < X_2 < X_3.$$
$$\Pi = S_T - X_1 - C_1 + 2C_2 - C_3 \qquad \text{if } X_1 < S_T \leq X_2 < X_3.$$
$$\begin{aligned}\Pi &= S_T - X_1 - C_1 - 2S_T + 2X_2 + 2C_2 - C_3 \\ &= -S_T + 2X_2 - X_1 - C_1 + 2C_2 - C_3 \qquad \text{if } X_1 < X_2 < S_T \leq X_3.\end{aligned}$$
$$\begin{aligned}\Pi &= S_T - X_1 - C_1 - 2S_T + 2X_2 + 2C_2 + S_T - X_3 - C_3 \\ &= -X_1 + 2X_2 - X_3 - C_1 + 2C_2 - C_3 \qquad \text{if } X_1 < X_2 < X_3 < S_T.\end{aligned}$$

MAKING THE CONNECTION

Designing a Collar for an Investment Portfolio

Avalon Asset Management (AAM) is a (fictional) small investment management company with \$50 million of assets under management. Its performance is measured at the end of the calendar year. Through nine months this year, AAM has earned outstanding returns for its clients, with its overall portfolio up about 21 percent. AAM is, however, concerned about the fourth quarter. AAM management has worked hard for this performance year to date and would not want to see it evaporate.

A partner has learned of the collar strategy, which would enable the company to purchase insurance against downside losses, in the form of puts, by selling off some of its upside gains, in the form of calls. AAM has never used options before but believes that it understands the risks and rewards. It is not authorized, however, to use options for any of its client accounts. The partners decide to experiment with the collar strategy using \$500,000 from the company's pension fund. The partners know that the collar is a conservative strategy and will not jeopardize the pension fund.

The partners approach First National Dealer Bank (FNDB) with a request to purchase a collar covering \$500,000 of the portfolio. FNDB knows that this is a small derivatives transaction, which it would ordinarily not do, but it knows that if AAM is satisfied with this strategy, it will likely do larger transactions later. The bank knows that it can do the transaction and hedge the risk in the stock index options market. It also believes that it can buy and sell the options at slightly better prices than it would give AAM, thereby covering its costs and generating a small profit.

FNDB asks AAM about the amount of downside risk it is willing to bear. AAM feels it can tolerate a loss of about 6 percent in the fourth quarter so that its overall annual return would be about 15 percent. The S&P 500 is currently at 1,250, so a 6 percent loss from that would put it at $1{,}250(1 - 0.06) = 1{,}175$. Thus, the put option would have an exercise price of 1,175. The expiration is three months, so $T = 3/12 = 0.25$. The S&P 500 dividend yield is 1.5 percent, the estimated volatility is 0.2, and the risk-free rate is 4 percent.

Given these inputs, a put with an exercise price of 1,175 would have a price of \$17.74. An exercise price of 1,352 would produce a call premium of \$17.76. FNDB agrees to round the call premium to \$17.74. So the call will be struck at 1,352 and the put at 1,175. Thus, on the upside, the index can increase by 8.16 percent before the gain is lost. On the downside, the index can fall by 6 percent before the put stops the loss. Because the S&P 500 is at 1,250 and the transaction covers a \$500,000 portfolio, there will be 400 individual options.

FNDB is concerned about one point. What if AAM's portfolio does not perform identically to the S&P 500? It discusses this with AAM, which says that its portfolio sensitivity to the S&P 500 is about 101 percent. In technical terms, the beta is 1.01. AAM is satisfied that this is a close enough match to the S&P 500. FNDB is not so sure but believes that the risk is worth taking. So the collar is executed.

During the final three months of the year, the market surprisingly continues to perform well. The portfolio rises 7.5 percent to \$537,500. The S&P 500, however, outperforms the portfolio, increasing at a 10 percent rate to 1,375. The call options expire in-the-money, and AAM must pay $400\text{Max}(0, 1{,}375 - 1{,}352) = \$9{,}200$. This effectively reduces the value of the overall position to $\$537{,}500 - \$9{,}200 = \$528{,}300$. The rate of return is, therefore,

$$\frac{\$528{,}300}{\$500{,}000} - 1 = 0.0566.$$

This is an overall return of a little over three-fourths of what the portfolio earned. The partners are confused. They believed they had room on the upside to earn the full return up to about 8 percent. With their portfolio slightly more volatile than the market, they believed that if they lost anything, it would be the excess of the portfolio's performance relative to the S&P 500. So what happened?

The portfolio underperformed the S&P 500. Even though the portfolio was thought to be more volatile than the S&P 500, measuring a portfolio's volatility is difficult. With the portfolio underperforming the S&P 500, the short call expired in-the-money without a corresponding gain on the portfolio to offset. Had the portfolio grown by 10 percent, the performance of the S&P 500, its value would have been \$550,000. Deducting the \$9,200 payoff on the call, the total value would have been $\$550{,}000 - \$9{,}200 = \$540{,}800$, a gain of 8.16 percent, which is the precise upside margin built into the collar.

AAM attempted to protect a portfolio using options in which the underlying was not identical to the portfolio. Whether it uses the collar strategy again will depend on its tolerance for small discrepancies in performance from its target. AAM is, however, generally pleased because its annual performance was enhanced through its fourth-quarter performance, although not as much as its performance would otherwise have been.

Now look at the first profit equation, $-C_1 + 2C_2 - C_3$. This can be separated into $-C_1 + C_2$ and $C_2 - C_3$. We already know that a low-exercise-price call is worth more than a high-exercise-price call. Thus, the first pair of terms is negative and the second pair is positive. Which pair will be greater in an absolute sense? The first pair will. The advantage of a low-exercise-price call over a high-exercise-price call is smaller at higher exercise prices because there the likelihood of both calls expiring out-of-the-money is greater. If that happens, neither call will be of any value to the trader. Because $-C_1 + C_2$ is larger in an absolute sense than $C_2 - C_3$, the profit for the lowest range of stock prices at expiration is negative.

For the second range, the profit is $S_T - X_1 - C_1 + 2C_2 - C_3$. The last three terms, $-C_1 + 2C_2 - C_3$, represent the net price paid for the butterfly spread. Because the stock price at expiration has a direct effect on the profit, a graph would show the profit varying dollar for dollar in a positive manner with the stock price at expiration. The profit in this range of stock prices can, however, be either positive or negative. This implies that there is a breakeven stock price at expiration. To find that stock price, S_T^* set this profit equal to zero:

$$S_T^* - X_1 - C_1 + 2C_2 - C_3 = 0.$$

Solving for S_T^* gives

$$S_T^* = X_1 + C_1 - 2C_2 + C_3.$$

The breakeven equation indicates that a butterfly spread is profitable if the stock price at expiration exceeds the low exercise price by an amount large enough to cover the net price paid for the spread.

Now look at the third profit equation. Because the profit varies inversely dollar for dollar with the stock price at expiration, a graph would show the profit decreasing one for one with the stock price at expiration. The profit can be either positive or negative; hence, there is a second breakeven stock price. To find it, set the profit equal to zero:

$$-S_T^* + 2X_2 - X_1 - C_1 + 2C_2 - C_3 = 0.$$

Solving for S_T^* gives

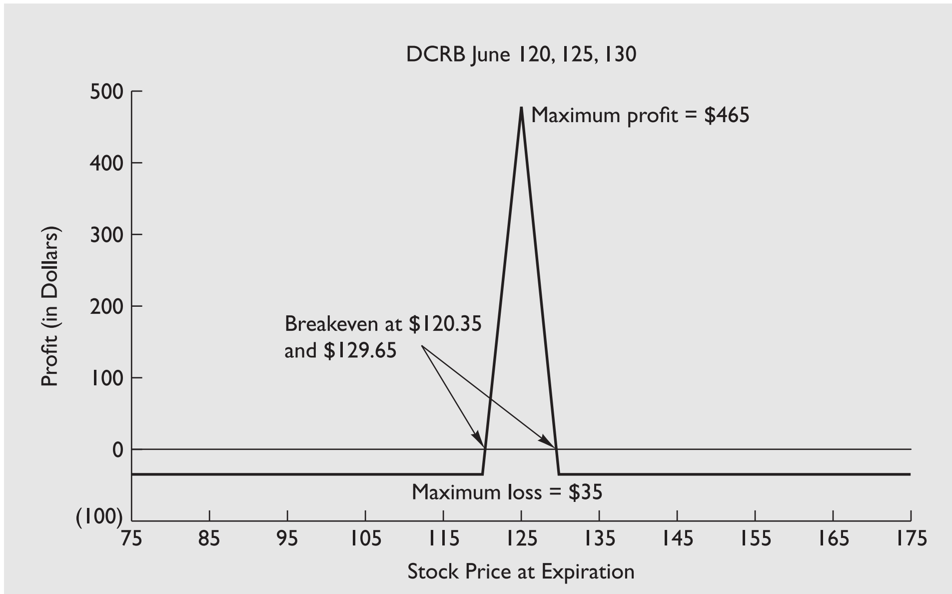
$$S_T^* = 2X_2 - X_1 - C_1 + 2C_2 - C_3.$$

Recall that in this range of stock prices, the profit declines with higher stock prices. Profit will disappear completely if the stock price is so high that it exceeds the cash flow received from the exercise of the middle-exercise-price call, $2X_2$, minus the cash flow paid for the exercise of the low-exercise-price call, X_1, minus the net premiums on the calls.

In the final range of the stock price at expiration, profit is the net premiums paid plus the difference in the exercise prices. Because X_2 is halfway between X_1 and X_3, then $X_2 - X_1$ is the same as $X_3 - X_2$. Therefore, $-X_1 + 2X_2 - X_3 = 0$. This means that the profit in this range is the same as that in the first range and is simply the difference in the premiums.

Now that we have a good idea of what a butterfly spread looks like, consider the DCRB June 120, 125, and 130 calls. In this example, a plot of the results would reveal that the butterfly spread would profit at any stock price. Upon further inspection of the prices, we would see that the cost of buying the butterfly spread is less than the lowest possible value of the spread at expiration. Therefore, one or more of the options must be mispriced. To avoid any confusion about the performance of the butterfly spread, we should use theoretically correct prices, which can be obtained from the Black–Scholes–Merton model. Using the volatility of 83 percent, we would see that at a market

FIGURE 7.7 Call Butterfly Spread



price of \$15.40, the 120 call is significantly lower than its Black–Scholes–Merton value of about \$16. Thus, let us use \$16 as its price.

Figure 7.7 illustrates the butterfly spread for the June 120, 125, and 130 calls with premiums of \$16.00, \$13.50, and \$11.35, respectively. The worst outcome is simply the net premiums, or $100[-16.00 + 2(13.50) - 11.35] = -35$. This is obtained for any stock price less than \$120 or greater than \$130. The maximum profit is obtained when the stock price at expiration is at the middle exercise price. Using the second profit equation and letting $S_T = X_2$, the maximum profit is

$$\Pi = X_2 - X_1 - C_1 + 2C_2 - C_3,$$

which in this example is $100[125 - 120 - 16.00 + 2(13.50) - 11.35] = 465$. The lower breakeven is $X_1 + C_1 - 2C_2 + C_3$, which in this case is $120 + 16.00 - 2(13.50) + 11.35 = 120.35$. The upper breakeven is $2X_2 - X_1 - C_1 + 2C_2 - C_3$, which in this example is $2(125) - 120 - 16.00 + 2(13.50) - 11.35 = 129.65$.

The butterfly spread strategy assumes that the stock price will fluctuate very little. In this example, the trader is betting that the stock price will stay within the range of \$120.35, a downward move of 4.4 percent, to \$129.65, an upward move of 2.9 percent. If this prediction of low stock price volatility proves incorrect, however, the potential loss will be limited—in this case, to \$35. Thus, the butterfly spread is a low-risk transaction.

A trader who believes that the stock price will be extremely volatile and will fall outside of the two breakeven stock prices might want to write a butterfly spread. This will involve one short position in each of the X_1 and X_3 calls and two long positions in the X_2 call. We shall leave it as an end-of-chapter problem to explore the short butterfly spread.

Early exercise can pose a problem for holders of butterfly spreads. Suppose the stock price prior to expiration is S_t, where S_t is greater than or equal to X_2 and less than or equal to X_3. Assume that the short calls are exercised shortly before the stock goes ex-dividend. The spreader then exercises the long call with exercise price X_1. The cash flow from the short calls is $-(2S_t - 2X_2)$, and the cash flow from the long call is $S_t - X_1$. This gives a total cash flow of $-S_t + X_2 + X_2 - X_1$. The minimum value of this expression is $-X_2 + X_2 + X_2 - X_1 = X_2 - X_1$, which is positive. If S_t exceeds X_3 and the two short calls are exercised, they will be offset by the exercise of both long calls and the overall cash flow will be zero.

A butterfly spread has a limited loss, which occurs on large stock price moves, either up or down, and a limited gain, which occurs if the stock price ends up at the middle exercise price.

Thus, early exercise does not result in a cash outflow, but that does not mean that it poses no risk. If the options are exercised early, there is no possibility of achieving the maximum profit obtainable at expiration when $S_T = X_2$. If the spread were reversed and the X_1 and X_3 calls were sold while two of the X_2 calls were bought, early exercise could generate a negative cash flow.

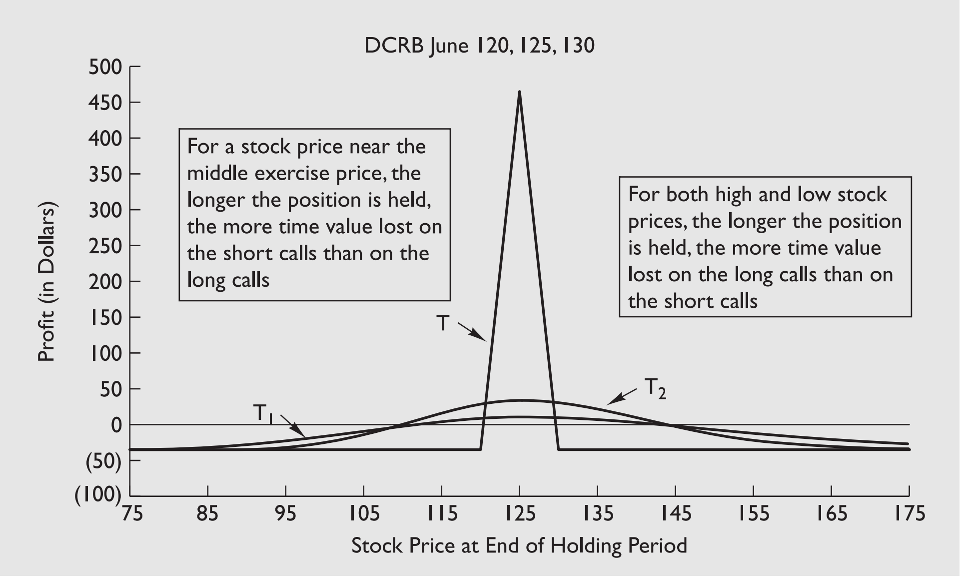
Choice of Holding Period As with any option strategy, the investor might wish to close the position prior to expiration. Consider the June 120, 125, and 130 calls. Let us continue to use the same prices used in the preceding example: \$16.00, \$13.50, and \$11.35, respectively. Let holding period T_1 involve closing the position on June 1 and holding period T_2 close the position on June 11.[1] The graph is shown in Figure 7.8.

For a given stock price, the profit of a butterfly spread increases as expiration approaches if the stock price is near the middle exercise price and decreases if the stock price is on the low or high side.

At high stock prices, time value will be greatest on the call with the highest exercise price. Because we are long that call, we gain the advantage of being able to sell it back early and recapture some of the time value. This advantage, however, erodes with a longer holding period because the time value decreases.

At low stock prices, the time value will be greatest on the call with the lowest exercise price. Because we are also long that call, we can sell it back early and recapture some of its remaining time value. This advantage also decreases, however, as we hold the position longer and time value decays.

FIGURE 7.8 Call Butterfly Spread: Different Holding Periods



[1]The holding period was changed in this example because the time value decay does not show up as clearly for the holding periods we have previously used.

In the middle range of stock prices, the time value will be very high on the two short calls. For short holding periods, this is a disadvantage because we have to buy back these calls, which means that we must pay for the remaining time value. This disadvantage turns to an advantage, however, as the holding period lengthens and time value begins to disappear. At expiration, no time value remains; thus, profit is maximized in this range.

The breakeven stock prices are substantially further away with shorter holding periods. This is advantageous because it will then take a much larger stock price change to produce a loss.

As always, we cannot specifically identify an optimal holding period. Because the butterfly spread is a spread in which the trader expects the stock price to stay within a narrow range, profit is maximized with a long holding period. The disadvantage of a long holding period, however, is that it gives the stock price more time to move outside of the profitable range.

All the aforementioned spreads are money spreads. We now turn to an examination of calendar spreads.

7-3 CALENDAR SPREADS

A **calendar spread**, also known as a **time spread** or **horizontal spread**, involves the purchase of an option with one expiration date and the sale of an otherwise identical option with a different expiration date. Because it is not possible to hold both options until expiration, analyzing a calendar spread is more complicated than analyzing a money spread. Because one option expires before the other, the longest possible holding period would be to hold the position until the expiration of the shorter maturity option. Then the other option would have some remaining time value that must be estimated.

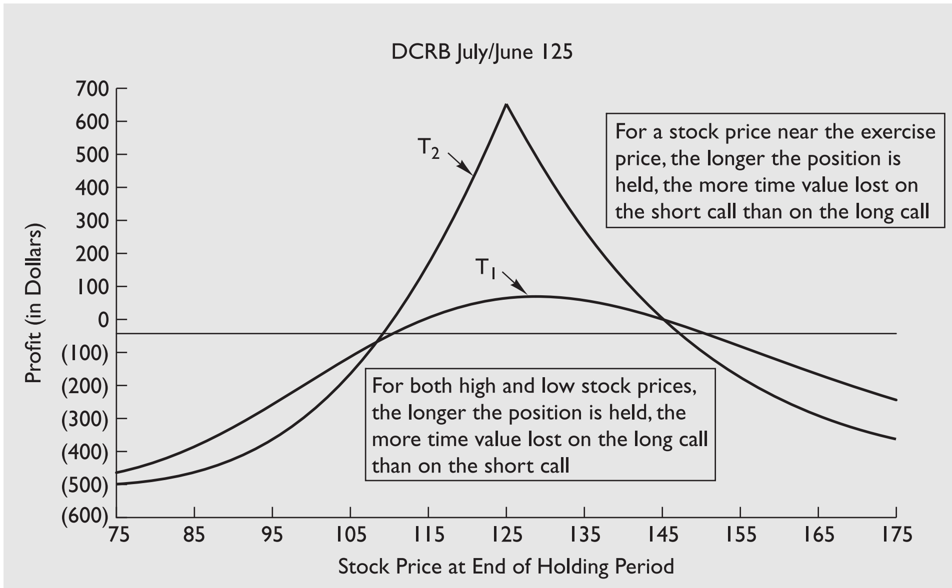
Because both options have the same exercise prices, they will have the same intrinsic values; thus, the profitability of the calendar spread will be determined solely by the difference in their time values. The longer-term call will have more time value. This does not, however, necessarily mean that one should always buy the longer-term call and sell the shorter-term call. As with most option strategies, which option is purchased and which one is sold depends on the investor's outlook for the stock.

To best understand the calendar spread, we will again illustrate with the DCRB calls. This spread consists of the purchase of the July 125 call at \$18.60 and the sale of the June 125 call at \$13.50. This position is net long because you pay more for the July than you receive for the June. Consider two possible holding periods. One, T_1, will involve the spread's termination on June 1; the other, T_2, will have the spread held until June 18, the date of the June call's expiration. Using the Black–Scholes–Merton model to estimate the remaining time values produces the graph in Figure 7.9.

Like the butterfly spread, the calendar spread is one in which the stock's volatility is the major factor in its performance. The investor obtains the greatest profit if the stock has low volatility and thus trades within a narrow range. If the stock price moves substantially, the investor will likely incur a loss.

How does the calendar spread work? Recall that we are short the June call and long the July call. When closing out the position, we buy back the June call and sell the July call. If the stock price is around the exercise price, both calls will have more time value remaining than if the stock price were at the extremes. The June call will always have less time value, however, than the July call on any given date. Thus, when we close out the position, the time value repurchased on the June call will be low relative to the remaining time value received from the sale of the July call. As we hold the position closer and closer to the June call's expiration, the remaining time value we must repurchase on that option will get lower and lower.

FIGURE 7.9 Call Calendar Spread



If the stock price is at the high or low extreme, the time values of both options will be low. If the stock price is high enough or low enough, there may be little, if any, time value on either option. Thus, when closing out the position, there may be little time value to recover from the July option. Because the July call is more expensive, we will end up losing money on the overall transaction.

The breakeven stock prices can be obtained only by visual examination.[2] In this example, the shorter holding period has a slightly wider range between its two breakeven stock prices—about $110 and $150. For the longer holding period, the lower breakeven is about $109 and the higher breakeven is still around $147.

An investor who expected the stock price to move into the extremes could execute a reverse calendar spread. This would require purchasing the June call and selling the July call. If the stock price became extremely low or high, there would be little time value remaining to be repurchased on the July call. Because the spreader received more money from the sale of the July call than was paid for the purchase of the June call, a profit would be made. If the stock price ended up around the exercise price, however, the trader could incur a potentially large loss. This is because the July call would possibly have a large time value that would have to be repurchased.

For a given stock price, a long calendar spread gains as expiration approaches if the stock price is near the exercise price and loses if the stock price is on the low or high side.

7-3a Time Value Decay

Because a calendar spread is completely influenced by the behavior of the two calls' time value decay, it provides a good opportunity to examine how time values decay. Using the Black–Scholes–Merton model, we can compute the week-by-week time values for each call during the spread's life, holding the stock price constant at $125.94. Keep in mind, of course, that time values will change if the stock price changes. Because time values are greatest for at-the-money options, we use the June and July 125 calls. The pattern of

[2]It is possible, however, to use a computer search routine with the Black–Scholes–Merton model to find the precise breakeven.

TABLE 7.2 TIME VALUE DECAY, JUNE AND JULY 125 AND CALENDAR SPREAD

	JUNE 125			JULY 125			SPREAD	
DATE	TIME	TIME VALUE	THETA	TIME	TIME VALUE	THETA	TIME VALUE	THETA
May 14	0.0959	12.61	−68.91	0.1726	17.14	−51.54	4.53	17.37
May 21	0.0767	11.22	−76.92	0.1534	16.12	−54.65	4.91	22.27
May 28	0.0575	9.64	−88.63	0.1342	15.04	−58.39	5.40	30.24
June 4	0.0384	7.77	−108.19	0.1151	13.88	−63.02	6.11	45.17
June 11	0.0192	5.35	−152.11	0.0959	12.62	−68.95	7.27	83.16
June 18	0.0000	0.00	0.00	0.0767	11.22	−76.96	11.22	−76.96

$\sigma = 0.83$, $S_0 = 125.94$, $r_c(\text{June}) = 0.0446$, $r_c(\text{July}) = 0.0453$
The spread time value and theta equal the time value and theta on the long July call minus the time value and theta on the short June call. The time value of each option is obtained as the Black–Scholes–Merton value, which is the intrinsic value plus the time value minus the intrinsic value of 0.94.

time values at various points during the options' lives is presented in Table 7.2. The table also presents the thetas, which we learned from Chapter 5 are the changes in the option prices for a very small change in time. Negative thetas imply that the option price will fall as we move forward in time.

Notice what happens as expiration approaches. Because of the June call's earlier expiration, its theta is more negative, and its time value decays more rapidly than does that of the July call. Because we are long the July call and short the June call, the spread's time value—the time value of the long call minus the time value of the short call—increases, as indicated by its positive theta. Once the June call expires, however, we are left with a long position in the July call, which leaves us with a negative theta. Time value will then begin decaying.

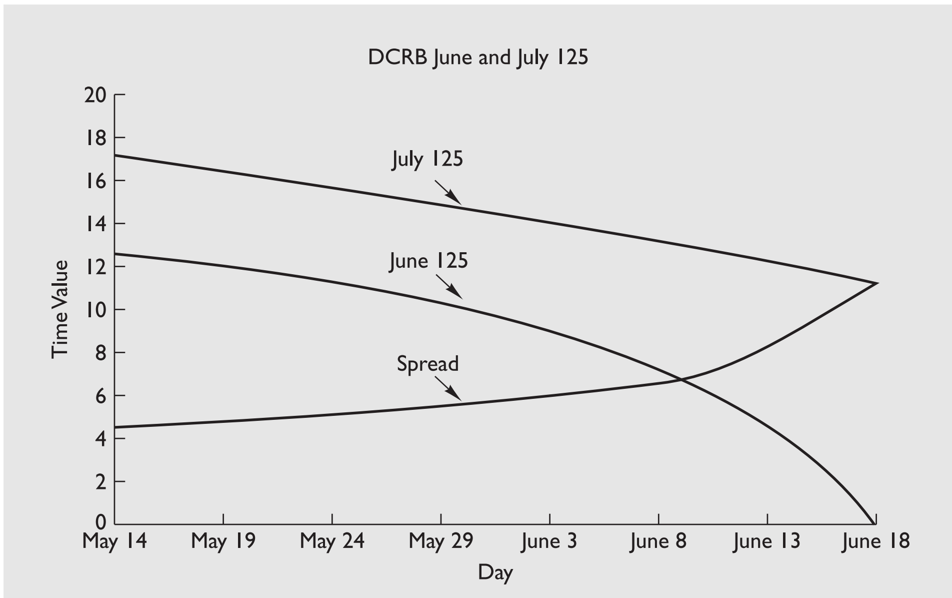
Figure 7.10 illustrates the pattern of time value decay. As expiration approaches, the time value of the June call rapidly decreases and the overall time value of the spread increases. At expiration of the June call, the spread's time value is composed entirely of the July call's time value.

Time value decays more rapidly as expiration approaches.

Time value decay would appear to make it easy to profit with a time spread. One would simply buy the longer-term option and write the shorter-term option. As the time values decayed, the spread would gain value. In reality, however, it seldom works out like this. The pattern of time value decay illustrated here was obtained by holding the stock price constant. In actuality, the stock price will almost surely change. Thus, there is indeed risk to a calendar spread. This risk is mitigated somewhat by the fact that the investor is long one option and short the other. Nonetheless, the calendar spread, in which one buys the long-term option and writes the short-term option, is a good strategy if one expects the stock price to remain fairly stable.

The degree of risk of early exercise on a calendar spread depends on which call is bought and which is sold. Because both calls have the same exercise price, the extent to which they are in-the-money is the same. As discussed in Chapter 3, however, the time to expiration is a factor in encouraging early exercise. We saw that if everything else is equal, the shorter-term option is the one more likely to be exercised early. Thus, if we write the shorter-term option, it could be exercised early. We always, however, have the choice of exercising the longer-term option early. It will certainly be in-the-money if the

FIGURE 7.10 Time Value Decay



shorter-term option is in-the-money. If S_t is the stock price prior to expiration and the shorter-term call is exercised, the cash flow will be $-(S_t - X)$, whereas the cash flow from exercising the longer-term option will be $S_t - X$. Thus, the total cash flow will be zero. This means that in the event of early exercise, there will be no negative cash flow. It does not mean that there will be no overall loss on the transaction.

The longer-term call is more expensive than the shorter-term call. This means that early exercise would ensure a loss by preventing us from waiting to capture the time value decay.

Calendar spreads can also be constructed with puts. By using the Black–Scholes–Merton model to determine the time value on the puts, similar results can be obtained. Like money spreads, put calendar spreads should not be overlooked. The puts could be mispriced, in which case a spread might offer the most profitable opportunity.

The butterfly spread and calendar spread are two of several transactions called **volatility strategies**. We shall look at the others later in this chapter. For now, however, note that all the strategies covered so far are risky. Some option traders prefer riskless strategies because if the options are mispriced, it may be possible to construct a riskless portfolio that will earn a return in excess of the risk-free rate.

7-4 RATIO SPREADS

Chapter 5 examined the Black–Scholes–Merton model. It showed that when an option is mispriced, an investor can construct a riskless hedge by buying an underpriced call and selling short the stock or by buying stock and selling an overpriced call. Because of margin requirements and other regulations, selling short stock can be complicated. By using spreads, however, the investor can buy an underpriced call and sell an overpriced or correctly priced call, producing a ratio of one call to the other that creates a riskless position. This transaction is called a **ratio spread**.

The ratio spread can be either a money spread or a calendar spread. Consider two calls priced at C_1 and C_2. Initially, we need not be concerned with which one is purchased and which one is sold, nor do we need to determine whether the two calls differ by time to expiration or by exercise price. The approach presented here can accommodate all cases.

Let the investor hold N_1 units of the call priced at C_1 and N_2 units of the call priced at C_2. The value of the portfolio is

$$V = N_1C_1 + N_2C_2.$$

Recall that the delta of a call is the change in the call price over the change in the stock price, assuming that the change in the stock price is very small. Let us use the symbols Δ_1 and Δ_2 as the deltas of the two calls. Remember that the deltas are the values of $N(d_1)$ from the Black–Scholes–Merton model. If the stock price changes, the first call generates a total price change of $N_1\Delta_1$ and the second call generates a total price change of $N_2\Delta_2$. Thus, when the stock price changes, the portfolio will change in value by the sum of these two values. A hedged position is one in which the portfolio value will not change when the stock price changes. Thus, we set $N_1\Delta_1 + N_2\Delta_2$ to zero and solve for the ratio N_1/N_2.

$$\frac{N_1}{N_2} = -\frac{\Delta_2}{\Delta_1}.$$

A riskless position is established if the ratio of the quantity of the first call to the quantity of the second call equals minus the inverse ratio of their deltas. The transaction would then be delta neutral.

Consider an example using the DCRB June 120 and 125 calls. Using $S_0 = 125.94$, $r_c = 0.0446$, and $T = 0.0959$ in the Black–Scholes–Merton model gives a value of $N(d_1)$ of 0.630 for the June 120 and 0.569 for the June 125. Thus, the ratio of the number of June 120s to June 125s should be $-(0.569/0.630) = -0.903$. Hence, the investor would buy 903 of the June 120s and sell 1,000 of the June 125s.

Note that the investor could have purchased 1,000 of the June 125s and sold 903 of the June 120s. The negative sign in the formula is a reminder to be long one option and short the other. An investor should, of course, always buy underpriced or correctly priced calls and sell overpriced or correctly priced calls.

If the stock price decreases by \$1, the June 120 should decrease by 0.630 and the June 125 by 0.569. The investor is long 903 of the June 120s and therefore loses $0.630(903) \approx 569$. Likewise, the investor is short 1,000 of the June 125s and thus gains $0.569(1{,}000) \approx 569$. The gain on one call offsets the loss on the other.

The ratio spread, of course, does not remain riskless unless the ratio is continuously adjusted. Because this is somewhat impractical, no truly riskless hedge can be constructed. Moreover, the values of $N(d_1)$ are simply approximations of the change in the call price for a change in the stock price. They apply for only very small changes in the stock price. For larger changes in the stock price, the hedger would need to consider the gamma, which we discussed in Chapter 5. Nonetheless, spreads of this type are frequently done by option traders attempting to replicate riskless positions. Although the positions may not always be exactly riskless, they will come very close to being so as long as the ratio does not deviate too far from the optimum.

A ratio spread is a risk-free transaction involving two options weighted according to their deltas.

This completes our coverage of option spread strategies. The next group of strategies is called **combinations** because they involve combined positions in puts and calls. We previously covered some combination strategies, namely conversions and reversals, which we used to illustrate put–call parity. The strategies covered in the remainder of this chapter are straddles and box spreads. We will use the same approach as before; the notation should be quite familiar to you by now.

A straddle is a strategy designed to profit if there is a large up or down move in the stock.

7-5 STRADDLES

Straddles, like calendar and butterfly spreads, are volatility strategies because they are based on the expectation of high or low volatility rather than the direction of the stock.

A **straddle** is the purchase of a call and a put that have the same exercise price and expiration date. By holding both a call and a put, the trader can capitalize on stock price movements in either direction.

Consider the purchase of a straddle with the call and put having an exercise price of X and an expiration of T. Then $N_C = 1$ and $N_P = 1$ and the profit from this transaction if held to expiration is

$$\Pi = \text{Max}(0, S_T - X) - C + \text{Max}(0, X - S_T) - P.$$

Because only one exercise price is involved, there are only two ranges of the stock price at expiration. The profits are as follows:

$$\begin{aligned} \Pi &= S_T - X - C - P \quad \text{if} \quad S_T \geq X. \\ \Pi &= X - S_T - C - P \quad \text{if} \quad S_T < X. \end{aligned}$$

For the first case, in which the stock price equals or exceeds the exercise price, the call expires in-the-money.[3] It is exercised for a gain of $S_T - X$, whereas the put expires out-of-the-money. The profit is the gain on the call minus the premiums paid on the call and the put. For the second case, in which the stock price is less than the exercise price, the put expires in-the-money and is exercised for a gain of $X - S_T$. The profit is the gain on the put minus the premiums paid for the put and the call.

For the range of stock prices above the exercise price, the profit increases dollar for dollar with the stock price at expiration. For the range of stock prices below the exercise price, the profit decreases dollar for dollar with the stock price at expiration. When the options expire with the stock price at the exercise price, both options are at-the-money and essentially expire worthless. The profit then equals the premiums paid, which, of course, makes it a loss. These results suggest that the graph is V-shaped. Figure 7.11 illustrates the straddle for the DCRB June 125 options. The dashed lines are the strategies of buying the call and the put separately.

As noted, the straddle is designed to capitalize on high stock price volatility. To create a profit, the stock price must move substantially in either direction. It is not necessary to know which way the stock will go; it is necessary only that it makes a significant move. How much must it move? Look at the two breakeven points.

For the case in which the stock price exceeds the exercise price, set the profit equal to zero:

$$S_T^* - X - C - P = 0.$$

Solving for S_T^* gives a breakeven of

$$S_T^* = X + C + P.$$

The upside breakeven is simply the exercise price plus the premiums paid for the options. For the case in which the stock price is below the exercise price, set the profit equal to zero:

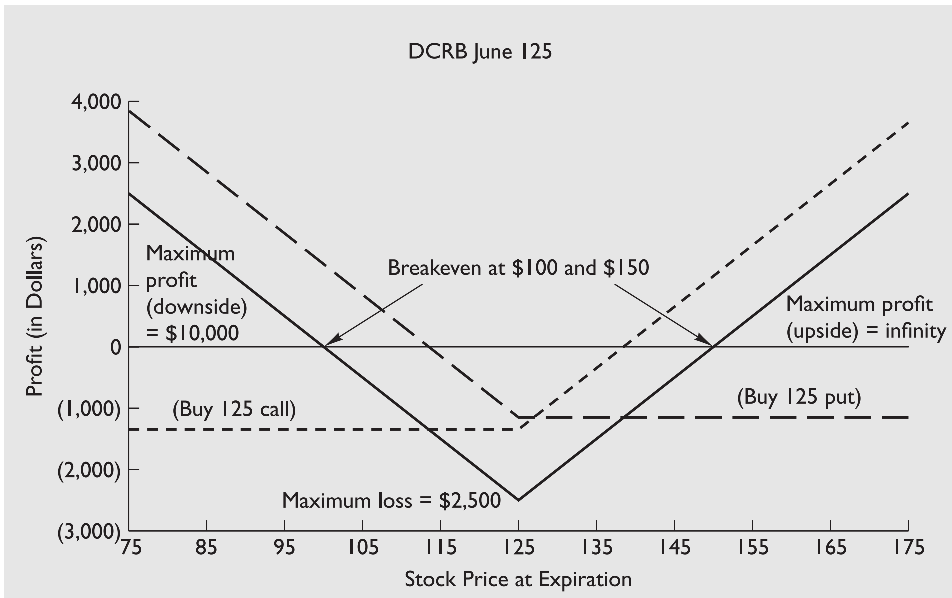
$$X - S_T^* - C - P = 0.$$

Solving for S_T^* gives a breakeven of

$$S_T^* = X - C - P.$$

[3] The case in which $S_T = X$ is included in this range. Even though $S_T = X$ means that the call is at-the-money, it can still be exercised for a gain of $S_T - X = 0$.

FIGURE 7.11 Straddle



The downside breakeven is the exercise price minus the premiums paid on the options.

Thus, the breakeven stock prices are simply the exercise price plus or minus the premiums paid for the call and the put. This makes sense. On the upside, the call is exercised for a gain equal to the difference between the stock price and the exercise price. For the investor to profit, the stock price must exceed the exercise price by enough that the gain from exercising the call will cover the premiums paid for the call and the put. On the downside, the put is exercised for a gain equal to the difference between the exercise price and the stock price. To generate a profit, the stock price must be sufficiently below the exercise price that the gain on the put will cover the premiums on the call and the put.

In this example, the premiums are $13.50 for the call and $11.50 for the put, for a total of $25. Thus, the breakeven stock prices at expiration are $125 plus or minus $25, or $100 and $150. The stock price currently is at $125.94. To generate a profit, the stock price must increase by $24.06 or decrease by $25.94 in the remaining 35 days until the options expire.

The worst-case outcome for a straddle is for the stock price to end up equal to the exercise price where neither the call nor the put can be exercised for a gain.[4] The option trader will lose the premiums on the call and the put, which in this example total $100(13.50 + 11.50) = 2{,}500$.

The profit potential on a straddle is unlimited. The stock price can rise infinitely, and the straddle will earn profits dollar for dollar with the stock price in excess of the exercise price. On the downside, the profit is limited simply because the stock price can go no lower than zero. The downside maximum profit is found by setting the stock price at expiration equal to zero for the case in which the stock price is below the exercise price. This gives a profit of $X - C - P$, which here is $100(125 - 13.50 - 11.50) = 10{,}000$.

[4]The put, the call, or both could be exercised, but the gain on either would be zero. Transaction costs associated with exercise would suggest that neither the call nor the put would be exercised when $S_T = X$.

The potentially large profits on a straddle can be a temptation too hard to resist. One should be aware that the straddle normally requires a fairly large stock price move to be profitable. Even to a novice investor, stock prices always seem highly volatile, but that volatility may be misleading. In this example, it would require about a 19 percent increase or a 21 percent decrease in the stock price in one month to make a profit, which would be a rare event. An investor considering a straddle is advised to carefully assess the probability that the stock price will move into the profitable range.

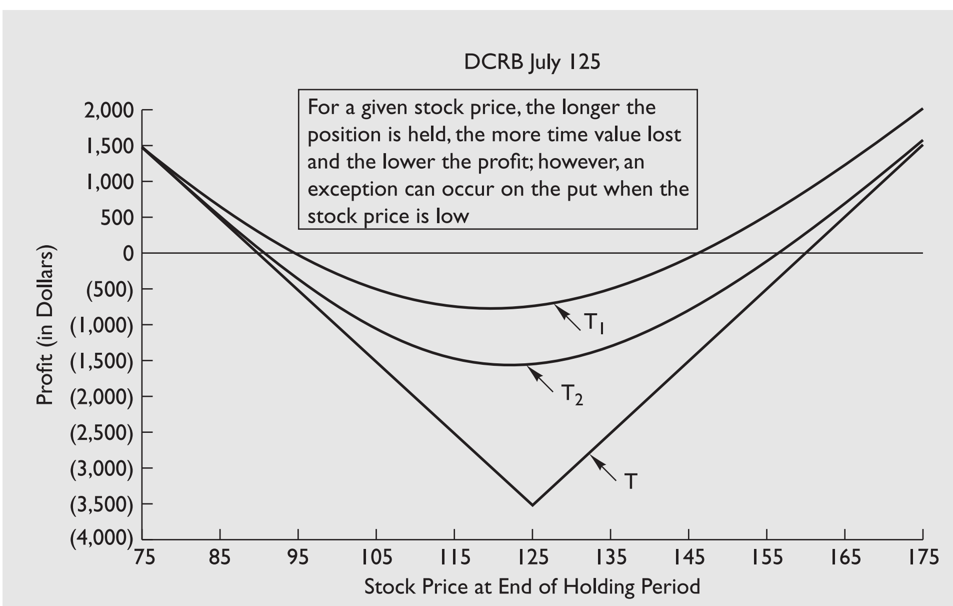
Because both the call and the put are owned, the problem of early exercise does not exist with a straddle. The early-exercise decision is up to the straddle holder. Transaction costs also need to be considered.

When the straddle is established, there is a commission on both the call and the put. At exercise, there will be a commission only on either the call or the put, whichever is in-the-money. Suppose the stock price ends up slightly higher than the exercise price. Because of the commission on the exercise of the call, it might be inadvisable to exercise the call even though it is in-the-money. A similar argument can be made for the case against exercising the put when the stock price ends up slightly less than the exercise price. This means that, as with any option strategy, the maximum loss is slightly more than the analysis indicates because of the commission. Moreover, the stock price at which such a loss occurs is actually a range around the exercise price.

7-5a Choice of Holding Period

Now consider what happens upon closing the position prior to expiration. Figure 7.12 illustrates the outcomes for the DCRB July 125 straddle using the same three holding periods employed in examining the other strategies;[5] that is, the shortest holding period involves closing the position on June 4, the intermediate-length holding period closes the

FIGURE 7.12 Straddle: Different Holding Periods



[5]Specifically, the holding period T means that the remaining maturity is 0.1151 based on 42 days remaining, T_2 means that the remaining maturity is 0.0575 based on 21 days remaining, and $T = 0$ assumes holding all the way to expiration.

position on June 25, and the long holding period closes the position at expiration. The profit graphs are curves that collapse onto the straight line for the case in which the position is held to expiration. The highest curve is the shortest holding period.

We should keep in mind that this graph does not imply that the shortest holding period is the best strategy. For a given stock price, the shortest holding period indeed provides the highest profit. The uncertainty of the stock price at expiration prevents the short holding period from dominating the longer holding periods. Because a straddle is designed to permit profiting from large stock price fluctuations, the short holding period leaves less time for the stock price to make a significant move.

When the straddle is closed out prior to expiration, both the call and the put will contain some remaining time value. If the stock price is extremely high or low, neither option will have much time value, but either the call or the put will have a high intrinsic value. If the stock price is close to the exercise price, both options will have a fair amount of time value. When closing out the position, the investor sells the options back and recovers this time value. As the holding period is extended closer to the expiration date, there is less time value to recover and the profit declines. The profit curve gradually decreases until, at expiration, it becomes the curve for the case in which the straddle is held to expiration. Thus, the higher profits from shorter holding periods come from recapturing the time value of the put and the call.

Figure 7.12 shows that the shorter holding period leads to a lower upside and higher downside breakeven. This reduces the risk to the trader because the range of stock prices in which a loss can be incurred is smaller. In this example, the shortest holding period has breakeven stock prices of about $93 and $146, and the intermediate-term holding period has breakeven stock prices of about $90 and $156.

For a given stock price, a straddle, being long two options, loses value as expiration approaches.

7-5b Applications of Straddles

A straddle is an appropriate strategy for situations in which one suspects that the stock price will move substantially but does not know in which direction it will go. An example of this occurs when a major bank or corporation is about to fail.

Suppose that a failing bank applies for a bailout from the government.[6] During the period in which the request is under consideration, a straddle will be a potentially profitable strategy. If the request is denied, the bank probably will fail and the stock will become worthless. If the bailout is granted, the bank may be able to turn itself around, in which case the stock price will rise substantially.

A similar scenario exists when a major corporation applies for federal loan guaranties. A straddle is also an appropriate strategy for situations in which important news is about to be released, and it is expected that the news will be either very favorable or very unfavorable. The weekly money supply announcements present opportunities that could be exploited with index options. Corporate earnings announcements are other examples of situations in which uncertain information will be released on a specific date.

The straddle certainly is not without risk. If investors already know or expect the information, the stock price may move very little when the announcement is made. If this happens, the investor might be tempted to hold on to the straddle in the faint hope that some other unanticipated news will be released before the options expire. In all likelihood, however, the stock price will move very little and the straddle will produce a loss. The trader might wish to cut the loss quickly by closing the position if the expected move does not materialize.

[6]Bailouts frequently take the form of loan guaranties but can also involve sale of unproductive assets or sale of new equity or hybrid securities.

The most important thing to remember when evaluating a straddle is to note that the greater uncertainty associated with the examples described here is recognized by everyone. Thus, the options would be priced according to a higher stock volatility, making the straddle more expensive. The most attractive straddles will be those in which the investor is confident that the stock will be more volatile than everyone else believes.

7-5c Short Straddle

An investor who expects the market to stay within a narrow trading range might consider writing a straddle. This would involve the sale of a put and a call with the same exercise price and expiration date. From the previous analysis, it should be obvious that the profit graph would be an inverted V. A short straddle would be a high-risk strategy because of the potential for large losses if the stock price moved substantially, particularly upward. Also, there would be the risk of early exercise of either the put or the call.

TAKING RISK IN LIFE **False Positives**

Finding out the truth concerning just about anything requires a systematic inquiry conducted with the utmost rigor. The typical procedure is to follow the scientific method of experimentation. With the scientific method, one develops a hypothesis, collects data, evaluates the data, calculates certain key statistics, and draws a conclusion. Even after doing so, however, we often have to admit that our conclusions are only accurate to a certain degree.

Suppose a new drug designed to treat arthritis is tested on a sample of people suffering from the disease. If one sample of people receives the drug and another receives a placebo, we can presumably measure the responses of the two groups and see if they are different. Assuming the group receiving the drug reports more improvements than the other group, we might conclude that the drug is effective. But how much "more" is required to justify such a conclusion? Suppose the two groups have 100 people in them and in the group receiving the drug five people reported improvements, whereas in the other group two people reported improvements. Is a difference of three enough to conclude that the drug is effective? If 10 people reported improvements in the group taking the drug, and only three reported improvements in the group taking the placebo, we might feel more confident that the drug is effective. And if the ratio was 20 to three, we would feel even better. But at what point does the ratio cross from leading us to conclude that the drug is ineffective to concluding that it is effective? The scientific method addresses this problem by assigning a probability that a conclusion of effectiveness is false. The wider the gap between the number of people reporting improvements with the drug and the number reporting improvements with the placebo, the lower the probability that a conclusion that the drug is effective is false. Researchers typically accept only a probability of 0.05 or less.

This probability captures what is referred to as a Type I error: concluding that a drug is effective when in fact it is not. There is also a Type II error that occurs when we conclude that the drug is not effective when in fact it is. Type II errors often arise in the form of what is known as *false positives*. False positives are a particularly serious concern in medical testing. Many basic medical tests do not lead to an unequivocal conclusion that a disease or condition is present. They merely provide a modest amount of information that suggests the possible presence of a disease. Further and more invasive and costly procedures are often required to draw a definitive conclusion that the person has or does not have the disease.

Gerd Gigerenzer in *Calculated Risk: How to Know When the Numbers Deceive You* (Simon and Schuster, 2002) gives an example in the diagnosis of breast cancer. The general statistic is that 0.8 percent of all 40-year-old women have breast cancer. The first line of testing for breast cancer is mammography, a type of picture of the internal structure of the breast. Mammography is relatively effective at detecting breast cancer. It will catch about 90 percent of all cases. Mammography, however, will also detect a variety of other conditions that are benign but could appear to be tumors. About 7 percent of the time, these other conditions will appear and lead a radiologist to believe that there could be a tumor present. With such evidence, a woman and her physician are likely to go to the next step of getting a biopsy, which is a surgical procedure that removes a small piece of tissue that is examined in a laboratory to determine if the tissue is malignant.

Gigerenzer posed this scenario to a sample of German physicians who averaged 14 years of experience. Suppose a woman receives a positive mammogram, meaning that a radiologist observes a suspicious area in the image. What is the probability that she has breast cancer? One-third of the physicians said about 90 percent. Another third said between 50 and 80 percent. Another third said 10 percent or lower. The median estimate was 70 percent. The correct answer is only about 9 percent. Let us see how such a low number is obtained. It is because of the effect of false positives.

Consider 1,000 women. If about 0.8 percent have breast cancer, we would expect about eight women to have the disease. With 90 percent accuracy in detecting breast cancer, a mammography should identify about seven of them. Of the remaining 992 women who do not have breast cancer, 7 percent or about 69 would be likely to have a positive mammogram and the remaining 923 would receive a negative result. These 69 women do have suspicious tissue, but most suspicious tissue is not cancer. Indeed, of the 77 women who receive a positive mammogram, only eight actually have the disease. Thus, having received a positive mammogram, the probability that a woman will have breast cancer is only $7/77 = 9.1$ percent.

False positives are the bane of medical tests, but some would argue that it is far better to be safe than sorry. That may well be the case, but in all likelihood, of the 1,000 women, 77 would have received biopsies and only seven would have benefitted. All in all, 1,000 women had to have a mammogram to catch eight cases. Frequent and rigorous physical examinations by both physicians and the women themselves in cases of a family history and other factors associated with a disposition toward breast cancer can almost surely catch some of these cases before they are too advanced. For these reasons, mammography has become controversial. In particular, for younger women (those in their 40s), studies have shown that mammography does not have any appreciable effect on breast cancer mortality. There are, however, measurable benefits for women in older age groups, though this effect tapers off and does not offer benefits by the time a woman reaches her mid-70s. Moreover, annual screening has been shown to be less effective than biennial screening, though many physicians still use annual screening.

Perhaps the most important lesson to learn from this story is that predicting risk is an exceedingly difficult exercise. Small pieces of information provide some evidence, but even those pieces of information are not definitive. When the stakes are a person's life, the decisions become even more difficult and agonizing than in the world of finance.

7-6 BOX SPREADS

A **box spread** is a combination of a bull call money spread and a bear put money spread. In contrast to the volatility strategies, the box spread is a low-risk—in fact, riskless—strategy.

Consider a group of options with two exercise prices, X_1 and X_2, and the same expiration. A bull call spread would involve the purchase of the call with exercise price X_1 at a premium of C_1 and the sale of the call with exercise price X_2 at a premium of C_2. A bear put spread would require the purchase of the put with exercise price X_2 at a premium of P_2 and the sale of the put with exercise price X_1 at a premium of P_1. Under the rules for the effect of exercise price on put and call prices, both the call and put spread would involve an initial cash outflow because $C_1 > C_2$ and $P_2 > P_1$. Thus, the box spread would have a net cash outflow at the initiation of the strategy.

The profit at expiration is

$$\begin{aligned}\Pi = {} & \text{Max}(0, S_T - X_1) - C_1 - \text{Max}(0, S_T - X_2) + C_2 \\ & + \text{Max}(0, X_2 - S_T) - P_2 - \text{Max}(0, X_1 - S_T) + P_1.\end{aligned}$$

Because there are two exercise prices, we must examine three ranges of the stock price at expiration. The profits are as follows:

$$\begin{aligned}\Pi &= -C_1 + C_2 + X_2 - S_T - P_2 - X_1 + S_T + P_1 \\ &= X_2 - X_1 - C_1 + C_2 - P_2 + P_1 && \text{if} \quad S_T \leq X_1 < X_2. \\ \Pi &= S_T - X_1 - C_1 + C_2 + X_2 - S_T - P_2 + P_1 \\ &= X_2 - X_1 - C_1 + C_2 - P_2 + P_1 && \text{if} \quad X_1 < S_T \leq X_2. \\ \Pi &= S_T - X_1 - C_1 + X_2 - S_T + C_2 - P_2 + P_1 \\ &= X_2 - X_1 - C_1 + C_2 - P_2 + P_1 && \text{if} \quad X_1 < X_2 < S_T.\end{aligned}$$

Notice that the profit is the same in each case: The box spread will be worth $X_2 - X_1$ at expiration, and the profit will be $X_2 - X_1$ minus the premiums paid, $C_1 - C_2 + P_2 - P_1$. The box spread is thus a riskless strategy. Why would anyone want to execute a box spread if one can more easily earn the risk-free rate by purchasing Treasury bills? The reason is that the box spread may prove to be incorrectly priced, as a valuation analysis can reveal.

Because the box spread is a riskless transaction that pays off the difference in the exercise prices at expiration, it should be easy to determine whether it is correctly priced. The payoff can be discounted at the risk-free rate. The present value of this amount is then compared to the cost of obtaining the box spread, which is the net premiums paid. This procedure is like analyzing a capital budgeting problem. The present value of the payoff at expiration minus the net premiums is a net present value (NPV). Because the objective of any investment decision is to maximize NPV, an investor should undertake all box spreads in which the NPV is positive. On those spreads with a negative NPV, one should execute a reverse box spread.

The NPV of a box spread is

$$\text{NPV} = (X_2 - X_1)(1 + r)^{-T} - C + C_2 - P_2 + P_1,$$

where r is the risk-free rate and T is the time to expiration.[7] If NPV is positive, the present value of the payoff at expiration will exceed the net premiums paid. If NPV is negative, the total amount of the premiums paid will exceed the present value of the payoff at expiration. The process is illustrated in Figure 7.13.

An alternative way to view the box spread is as the difference between two put–call parities. For example, for the options with exercise price X_1, put–call parity is

$$P_1 = C_1 - S_0 + X_1(1 + r)^{-T},$$

and for the options with exercise price X_2, put–call parity is

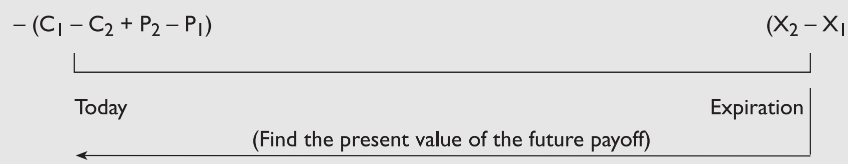
$$P_2 = C_2 - S_0 + X_2(1 + r)^{-T}.$$

Rearranging both equations to isolate the stock price gives

$$\begin{aligned}S_0 &= C_1 - P_1 + X_1(1 + r)^{-T} \text{ and} \\ S_0 &= C_2 - P_2 + X_2(1 + r)^{-T}.\end{aligned}$$

[7] Alternately, one could compute the present value of $X_2 - X_1$ as $(X_2 - X_3)e^{-r_c T}$ and obtain the same result.

FIGURE 7.13 The Box Spread



NPV = $(X_2 - X_1)(1 + r)^{-T} - (C_1 - C_2 + P_2 - P_1)$

If NPV > 0, execute the box spread.
If NPV < 0, execute a reverse box spread.

Because the left-hand sides are equal, the right-hand sides must also be equal; therefore,

$$C_1 - P_1 + X_1(1 + r)^{-T} = C_2 - P_2 + X_2(1 + r)^{-T}.$$

Rearranging this equation gives

$$0 = (X_2 - X_1)(1 + r)^{-T} - C_1 + C_2 - P_2 + P_1.$$

This is our put–call parity equation when the NPV is zero, which results if all puts and calls are correctly priced relative to one another.

Let us examine the DCRB June box spread using the 125 and 130 options. Consider the following transaction: Buy the 125 call at \$13.50, buy the 130 put at \$14.25, write the 130 call at \$11.35, and write the 125 put at \$11.50. The premiums paid for the 125 call and 130 put minus the premiums received for the 130 call and 125 put net out to \$4.90. Thus, it will cost \$490 to buy the box spread.

The payoff at expiration is $X_2 - X_1$. The NPV is

$$NPV = 100[(130 - 125)(1.0456)^{-0.0959} - 4.90] = \$7.85,$$

where 0.0456 is the discrete risk-free rate for June as determined in Chapter 3, and 0.0959 is the time to expiration from May 14 to June 18. Thus, the spread is underpriced and should be purchased. Had the NPV been negative, the box spread would have been overpriced and should have been sold. In that case, an investor would buy the 130 call and 125 put and sell the 125 call and 130 put. This would generate a positive cash flow up front that exceeded the present value of the cash outflow of $X_2 - X_1$ at expiration.

If the investor is holding a long box spread, the risk of early exercise is unimportant. Suppose the short call is exercised. Because the short call is in-the-money, the long call will be even deeper in-the-money. The investor can then exercise the long call. If the short put is exercised, the investor can, in turn, exercise the long put, which will be even deeper in-the-money than the short put. The net effect is a cash inflow of $X_2 - X_1$, the maximum payoff at expiration. For the short box spread, however, early exercise will result in a cash outflow of $X_2 - X_1$. Thus, the early exercise problem is an important consideration for short box spreads.

A box spread is a risk-free transaction in which the value can be easily calculated as the present value of a future payoff minus the initial outlay.

Transaction costs on a box spread will be high because four options are involved. At least two of the four options, however, will expire out-of-the-money. Nonetheless, the high transaction costs will make the box spread costly to execute for all but those who own seats on the exchange.

SUMMARY

This chapter showed how some of the basic option strategies introduced in Chapter 6 can be combined to produce more complex strategies, such as spreads and combinations. Spreads were shown to be relatively low-risk strategies. Money spreads can be designed to profit in a bull or a bear market. A collar uses both a long put and a short call, along with the underlying stock, and is similar to a bull money spread. Calendar spreads and butterfly spreads are used to profit in either the presence or the absence of high volatility. Straddles were also shown to be attractive in periods of high or low volatility. Finally, the chapter introduced the box spread, a riskless transaction that lends itself to a variation of a standard capital budgeting analysis with the end result being an NPV, a concept often encountered elsewhere in finance.

The strategies covered in this and the preceding chapter are but a few of the many possible option strategies. Those interested in furthering their knowledge of option strategies can explore the many excellent books cited in the references. The framework developed here should be sufficient to get you started. At this point, you should be capable of assessing the risks and rewards of a few simple option strategies. This book is an introduction and hopefully will encourage you to explore option strategies in more depth.

At one time, options, forward, and futures markets existed almost independently of each other. Now it is sometimes difficult to tell where one market ends and the other begins. Although we shall leave the world of options for a while, we will return to it in time.

Key Terms

Before continuing to Chapter 8, you should be able to give brief definitions of the following terms:

spread/vertical/strike/money spread/horizontal/time/calendar spread, p. 239
buying the spread/debit spread/ selling the spread/credit spread/ bull spread/bear spread, p. 240
collar, p. 247
butterfly/sandwich spread, p. 250
calendar/time/horizontal spread, p. 255
volatility strategies/ratio spread, p. 258
combinations, p. 259
straddle, p. 260
box spread, p. 265

Further Reading

More advanced analysis and option strategies can be found in the following:

Billingsley, R. S., and D. M. Chance. "Options Market Efficiency and the Box Spread Strategy." *Financial Review* 20 (November 1985): 287–301.

Cohen, G. *The Bible of Option Strategies: The Definitive Guide for Practical Trading Strategies*. Upper Saddle River, NJ: Financial Times Prentice Hall, 2005.

Dash, M., and A. Goel. "A Comparison of ITM and OTM Protective-Puts and Covered Calls." *Asian Journal of Finance & Accounting* 6 (2014): 126–137.

Doran, J. S., A. Fodor, and D. Jiang. "Call-Put Implied Volatility Spreads and Option Returns." *Review of Asset Pricing Studies* 3 (2013): 258–290.

Gombola, M. J., R. L. Roenfeldt, and P. L. Cooley. "Spreading Strategies in CBOE Options: Evidence on Market Performance." *Journal of Financial Research* 1 (Winter 1978): 35–44.

Isokov, D., and B. Morard. "Improving Portfolio Performance with Option Strategies: Evidence from Switzerland." *European Financial Management* 7 (2001): 73–91.

Jabbour, G., and P. H. Budwick. *The Option Trader Handbook: Strategies and Trade Adjustments*. Hoboken, NJ: John Wiley & Sons, 2010.

Johnson, K. E. *Option Spread Strategies: Trading Up, Down, and Sideways Markets*. New York: Bloomberg Financial, 2009.

Larcher, G., L. D. Chicca, and M. Szölgyenyi, "Modeling and Performance of Certain Put-Write Strategies." *Journal of Alternative Investments* 15 (Spring 2013): 74–86.

Slivka, R. T. "Risk and Return for Option Investment Strategies." *Financial Analysts Journal* 36 (September–October 1980): 67–73.

Slivka, R. T. "Call Option Spreading." *Journal of Portfolio Management* 7 (Spring 1981): 71–76.

The Options Institute. *Options: Essential Concepts and Trading Strategies*, 3rd ed. New York: McGraw-Hill, 1999.

Ungar, J., and M. T. Moran. "The Cash-Secured Put Write Strategy and Performance of Related Benchmark Indexes." *Journal of Alternative Investments* 4 (Spring 2009): 43–56.

Appendix B contains a more extensive bibliography of books, articles, and other materials and is located on the textbook companion site. To access, go to www.cengagebrain.com, search for ISBN 9781305104969, and click "Free Materials" tab and then "Access Now."

Concept Checks

1. Explain why option traders often use spreads instead of simple long or short options and combined positions of options and stock.
2. Suppose that an option trader has a call bull spread. The stock price has risen substantially, and the trader is considering closing the position early. What factors should the trader consider with regard to closing the transaction before the options expire?
3. Suppose that you are following the stock of a firm that has been experiencing severe problems. Failure is imminent unless the firm is granted government guaranteed loans. If the firm fails, its stock will, of course, fall substantially. If the loans are granted, it is expected that the stock will rise substantially. Identify two strategies that would be appropriate for this situation. Justify your answers.
4. Explain how a short call added to a protective put forms a collar and how it changes the payoff and up-front cost.
5. Explain the process by which the profit of a short straddle closed out prior to expiration is influenced by the time values of the put and call.

Questions and Problems

1. Derive the profit equations for a put bull spread. Determine the maximum and minimum profits and the breakeven stock price at expiration.
2. Explain why a straddle is not necessarily a good strategy when the underlying event is well known to everyone.
3. The chapter showed how analyzing a box spread is like a capital budgeting problem using the NPV approach. Consider the internal rate of return method of examining capital budgeting problems and analyze the box spread in that context.
4. One way to create a bull spread positions is by purchasing a low strike call option and selling a high strike call option. Identify a strategy with put options that creates a similar bull spread-shaped profit profile.
5. One way to create a bear spread positions is by purchasing a high strike put option and selling a low strike put option. Identify a strategy with call options that creates a similar bear spread-shaped profit profile.

The following option prices were observed for calls and puts on a stock on July 6 of a particular year. Use this information for problems 6 through 24. The stock was priced at 165.13. The expirations are July 17, August 21, and October 16. The continuously compounded risk-free rates associated with the three expirations are 0.0503, 0.0535, and 0.0571, respectively. The standard deviation is 0.21.

	Calls			Puts		
Strike	Jul	Aug	Oct	Jul	Aug	Oct
160	6.00	8.10	11.10	0.75	2.75	4.50
165	2.70	5.25	8.10	2.40	4.75	6.75
170	0.80	3.25	6.00	5.75	7.50	9.00

For problems 6 through 10 and 13 through 16, determine the profits for the holding period indicated for possible stock prices of 150, 155, 160, 165, 170, 175, and 180 at the end of the holding period. Answer any other questions as indicated. Note: Your Excel spreadsheet OptionStrategyAnalyzer10e.xlsm will be useful here for obtaining graphs as requested, but it does not allow you to calculate the profits for several user-specified asset prices. It lets you specify one *asset price and a maximum and minimum. Use OptionStrategyAnalyzer10e.xlsm to produce the graph for the range of prices from 150 to 180, but determine the profits for the prices of 150, 155, …, 180 by hand for positions held to expiration. For positions closed prior to expiration, use the spreadsheet BlackScholesMertonBinomial10e.xlsm to determine the option price when the position is closed; then calculate the profit by hand.*

6. Construct a bear money spread using the October 165 and 170 calls. Hold the position until the options expire. Determine the profits and graph the results. Identify the breakeven stock price at expiration and the maximum and minimum profits. Discuss any special considerations associated with this strategy.
7. Repeat problem 6, but close the position on September 20. Use the spreadsheet to find the profits for the possible stock prices on September 20. Generate a graph and use it to identify the approximate breakeven stock price.
8. Construct a collar using the October 160 put. First, use the Black–Scholes–Merton model to identify a call that will make the collar have zero up-front cost. Then close the position on September 20. Use the spreadsheet to find the profits for the possible stock prices on September 20. Generate a graph and use it to identify the approximate breakeven stock price. Determine the maximum and minimum profits.
9. Suppose you are expecting the stock price to move substantially over the next three months. You are considering a butterfly spread. Construct an appropriate butterfly spread using the October 160, 165, and 170 calls. Hold the position until expiration. Determine the profits and graph the results. Identify the two breakeven stock prices and the maximum and minimum profits.
10. Construct a calendar spread using the August and October 170 calls that will profit from high volatility. Close the position on August 1. Use the spreadsheet to find the profits for the possible stock prices on August 1. Generate a graph and use it to estimate the maximum and minimum profits and the breakeven stock prices.
11. Using the Black–Scholes–Merton model, compute and graph the time value decay of the October 165 call on the following dates: July 15, July 31, August 15, August 31, September 15, September 30, and October 16. Assume that the stock price remains constant. Use the spreadsheet to find the time value in all the cases.
12. Consider a riskless spread with a long position in the August 160 call and a short position in the October 160 call. Determine the appropriate hedge ratio. Then show how a $1 stock price increase would have a neutral effect on the spread value. Discuss any limitations of this procedure.
13. Construct a long straddle using the October 165 options. Hold until the options expire. Determine the profits and graph the results. Identify the breakeven stock prices at expiration and the minimum profit.
14. Repeat the previous problem, but close the positions on September 20. Use the spreadsheet to find the profits for the possible stock prices on September 20. Generate a graph and use it to identify the approximate breakeven stock prices.
15. A slight variation of a straddle is a strap, which uses two calls and one put. Construct a long strap using the October 165 options. Hold the position until expiration. Determine the profits and graph the results. Identify the breakeven stock prices at expiration and the minimum profit. Compare the results with the October 165 straddle.
16. A strip is a variation of a straddle involving two puts and one call. Construct a short strip using the August 170 options. Hold the position until the options expire. Determine the profits and graph the results. Identify the breakeven stock prices at expiration and the minimum profit.
17. Analyze the August 160/170 box spread. Determine whether a profit opportunity exists. If it does, explain how to exploit it.
18. Complete the following table with the correct formula related to various spread strategies.

Item	Bull Spread with Calls	Bear Spread with Puts	Butterfly Spread with Calls
Value at expiration			
Profit			
Maximum profit			
Maximum loss			
Breakeven			and

19. Complete the following table with the correct formula related to various spread strategies.

Item	Collar Strategies with Calls and Puts	Straddle with Calls and Puts
Value at expiration		
Profit		
Maximum profit		
Maximum loss		
Breakeven		and

20. Explain conceptually the choice of strike prices when it comes to designing a call-based bull spread. Specifically, address the costs and benefits of two bull spread strategies. One strategy has the call strike prices further from the current stock price than the second strategy.
21. Explain conceptually the choice of strike prices when it comes to designing a zero-cost collar. Specifically, address the costs and benefits of two strategies. One strategy has a higher put strike price than the second strategy.
22. Pear, Inc. is presently trading at $100 per share; at-the-money one-month calls are trading at $5.43, and puts are trading at $5.01; and at-the-money two-month calls are trading at $7.72, and puts are trading at $6.89. At present, these option prices reflect a Black–Scholes–Merton implied volatility of 45 percent for all options. You believe, however, that the volatility over the next month will be lower than 45 percent and the volatility in the second month will be higher than 45 percent because you think Pear, Inc. will publicly schedule an earnings announcement in 45 days and there will be an information blackout period leading up to the announcement. A blackout period occurs when a company does not provide any information to the public for a stated period of time. The earnings announcement will cause higher volatility, and the blackout period will result in lower volatility. Design an option strategy using all four options that will profit if you are correct in your volatility belief, the company publicly schedules the announcement within the next few days, and option prices immediately adjust to these beliefs.
23. (Concept Problem) Another variation of the straddle is called a *strangle*. A strangle is the purchase of a call with a higher exercise price and a put with a lower exercise price. Evaluate the strangle strategy by examining the purchase of the August 165 put and 170 call. As in earlier problems, determine the profits for stock prices of 150, 155, 160, 165, 170, 175, and 180. Hold the position until expiration and graph the results. Find the breakeven stock prices at expiration. Explain why one would want to use a strangle.
24. (Concept Problem) Many option traders use a combination of a money spread and a calendar spread called a *diagonal spread*. This transaction involves the purchase of a call with a lower exercise price and longer time to expiration and the sale of a call with a higher exercise price and shorter time to expiration. Evaluate the diagonal spread that involves the purchase of the October 165 call and the sale of the August 170 call. Determine the profits for the same stock prices you previously examined under the assumption that the position is closed on August 1. Use the spreadsheet to find the profits for the possible stock prices on August 1. Generate a graph and use it to estimate the breakeven stock price at the end of the holding period.
25. (Case) Professors Don Chance of Louisiana State University and Michael Hemler of the University of Notre Dame have authored an options trading case that corresponds to the material in this and the preceding chapter. Go to www.cengagebrain.com and use ISBN 9781305104969 to access the student product support website and download Second City Options case.