
Volatility Spreads

In Chapter 8, we showed that it is possible, at least in theory, to capture an option's mispricing in the marketplace by employing a dynamic hedging strategy. The first step in this process involves hedging the option position, delta neutral, by taking an opposing market position in the underlying contract. But the underlying contract is not the only way in which we can hedge an option position. We might instead take our opposing delta position with other options.

Consider a call with a delta of 50 that appears to be underpriced in the marketplace. If we buy 10 calls, resulting in a delta position of +500, we might hedge the position in any of the following ways:

- Sell five underlying contracts.

- Buy puts with a total delta of -500 .

- Sell calls, different from those that we purchased, with a total delta of -500 .

- Do a combination of any of the preceding such that we create a total delta of -500 .

There are clearly many different ways of hedging our 10 calls. Regardless of which method we choose, each spread will have certain features in common:

- Each spread will be approximately delta neutral.

- Each spread will be sensitive to changes in the price of the underlying instrument.

- Each spread will be sensitive to changes in implied volatility.

- Each spread will be sensitive to the passage of time.

Spreads with the foregoing characteristics fall under the general heading of *volatility spreads*. In this chapter, we will look at the most common types of volatility spreads, initially by examining their expiration values and then by considering their delta, gamma, theta, vega, and rho characteristics.

Straddle

A *straddle* consists of a call and a put where both options have the same exercise price and expiration date. In a straddle, both options are either purchased (a *long straddle*) or sold (a *short straddle*). Examples of long and short straddles, with their expiration profit-and-loss (P&L) graphs, are shown in Figures 11-1 and 11-2.

At expiration, the value of a straddle can be expressed as a simple parity graph. But what about its value prior to expiration? As with all option positions, some changes in market conditions will help the strategy and some changes will hurt. From Figure 11-1, we can see that a long straddle becomes more valuable when the underlying market moves away from the exercise price and less valuable as time passes if no movement occurs. At the same time, any increase in volatility will help, while any decline will hurt. These characteristics are indicated by the risk measures associated with the position:

- +Gamma (desire for movement in the underlying contract)
- Theta (the value of the position declines as time passes)
- +Vega (the value of the position increases as implied volatility rises)

The characteristics of a short straddle are shown in Figure 11-2:

- Gamma (movement in the underlying contract will hurt the position)
- +Theta (the value of the position increases as time passes)
- Vega (the value of the position increases as implied volatility falls)

Figure 11-1 Long straddle as time passes or volatility declines.

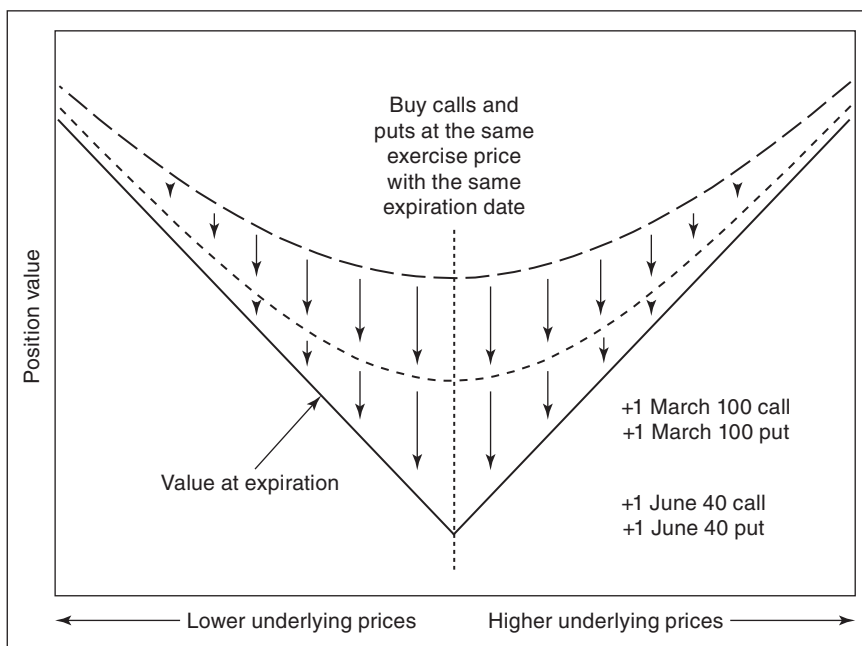
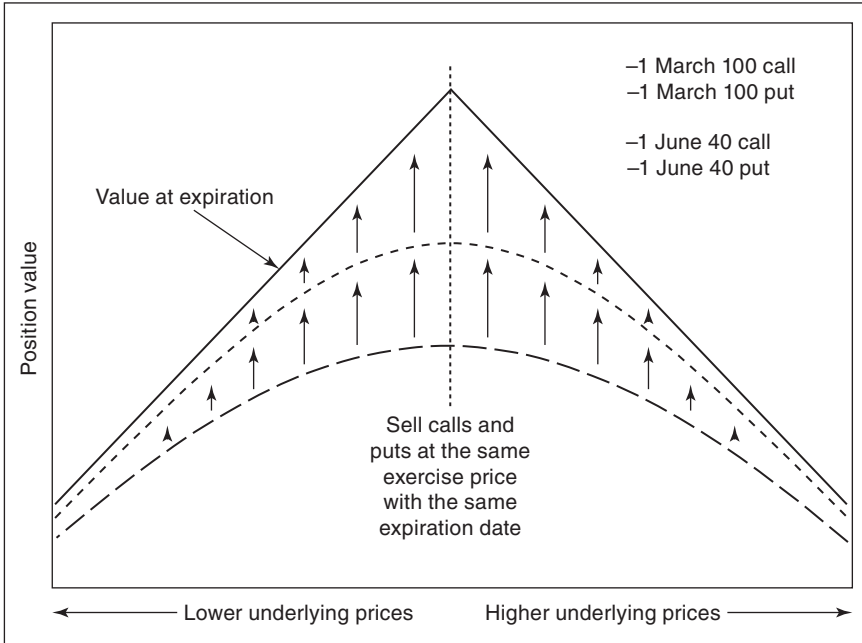


Figure 11-2 Short straddle as time passes or volatility declines.



Straddles are most often executed one to one (one call for each put) using at-the-money options. When this is done, the spread will be approximately delta neutral because the delta values of the call and put will be close to 50 and -50 . A straddle can also be done with options that are either in the money or out of the money. For example, with the underlying contract trading at 100, we might buy the September 95 straddle. If the September 95 calls, which are in the money, have a delta of 75 and the September 95 puts, which are out of the money, have a delta of -25 , the total delta will be $75 - 25 = 50$, resulting in a *bull straddle*. If we want the straddle to be delta neutral, we will need to adjust the number of contracts by purchasing three puts for every call:

- Buy 1 September 95 call (delta = 75).
- Buy 3 September 95 puts (delta = -25).

This spread still qualifies as a straddle because we are buying calls and puts at the same exercise price. But, more specifically, this is a *ratio straddle* because the number of long market contracts (the calls) and the number of short market contracts (the puts) are unequal.

Strangle

Like a straddle, a *strangle* consists of a long call and a long put (a long strangle) or a short call and a short put (a short strangle), where both options expire

at the same time. But in a strangle the options have different exercise prices. Typical long and short strangles are shown in Figures 11-3 and 11-4.

As with a straddle, strangles are most often done one to one (one call for each put). In order to ensure that the position is delta neutral, exercise prices are usually chosen so that the call and put deltas are approximately equal.

If a strangle is identified only by its expiration month and exercise prices, there may be some confusion as to the specific options involved. A March 90/110 strangle might consist of a March 90 put and a March 110 call. But it might also consist of a March 90 call and a March 110 put. Both strategies are consistent with the definition of a strangle. To avoid confusion, a strangle is commonly assumed to consist of out-of-the-money options. If the underlying market is currently at 100 and a trader wants to purchase the March 90/110 strangle, everyone will assume that he wants to purchase a March 90 put and a March 110 call. Although both strangles have essentially the same P&L profile, in-the-money options tend to be less actively traded than their out-of-the-money counterparts. A strangle consisting of in-the-money options is sometimes referred to as a *guts*.

Note that the risk characteristics of a strangle are similar to those of a straddle:

Long strangle: +gamma/−theta/+vega

Short strangle: +gamma/−theta/+vega

A new option trader often finds long straddles and strangles attractive because strategies with limited risk and unlimited profit potential offer great appeal, especially when the profit is unlimited in both directions. However,

Figure 11-3 Long strangle as time passes or volatility declines.

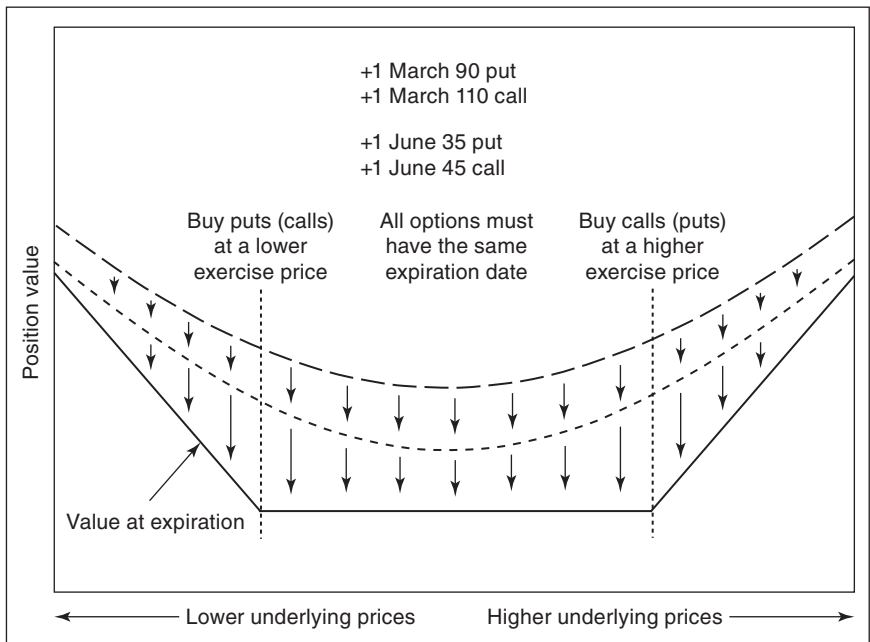
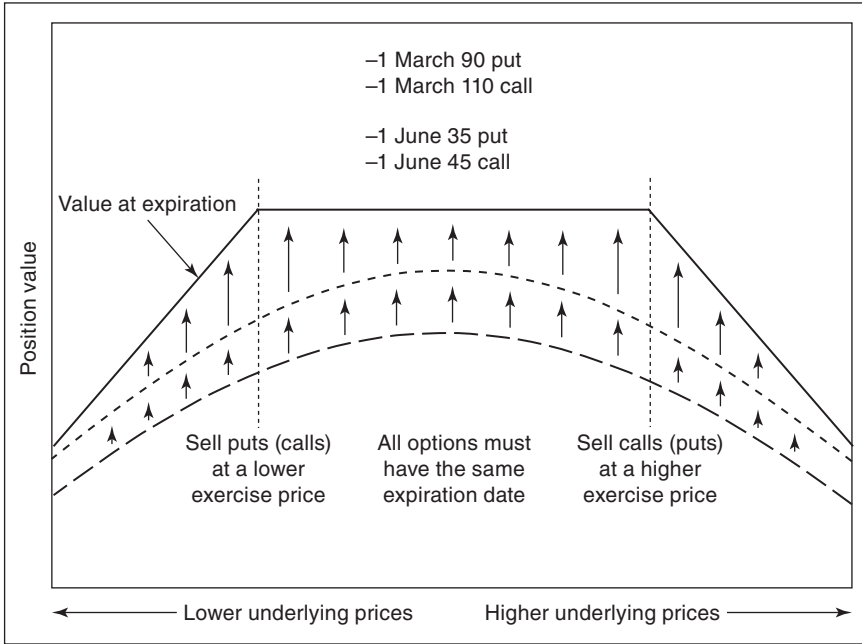


Figure 11-4 Short strangle as time passes or volatility declines.



if the hoped-for movement fails to materialize, a trader will find that losing money, even a limited amount, can also be a painful experience. This is not an endorsement of either long or short straddles. Under the right conditions, either strategy may be sensible. But an intelligent trader needs to consider not only whether the risk and reward is limited or unlimited but also the likelihood of the various outcomes. This, of course, is one important reason for using a theoretical pricing model.

Butterfly

Thus far we have looked at spreads that involve buying or selling two different option contracts. However, we can also construct spreads consisting of three, four, or even more different options. A *butterfly* is a common three-sided spread consisting of options with equally spaced exercise prices, where all options are of the same type (either all calls or all puts) and expire at the same time. In a long butterfly, the outside exercise prices are purchased and the inside exercise price is sold, and vice versa for a short butterfly. Moreover, the ratio of a butterfly never varies. It is always $1 \times 2 \times 1$, with two of each inside exercise price traded for each one of the outside exercise prices. Typical long and short butterflies are shown in Figures 11-5 and 11-6.

To a new trader, a butterfly may look quite complex since it involves three different options in different quantities. But butterflies have very simple and well-defined characteristics that make them popular trading strategies.

Figure 11-5 Long butterfly as time passes or volatility declines.

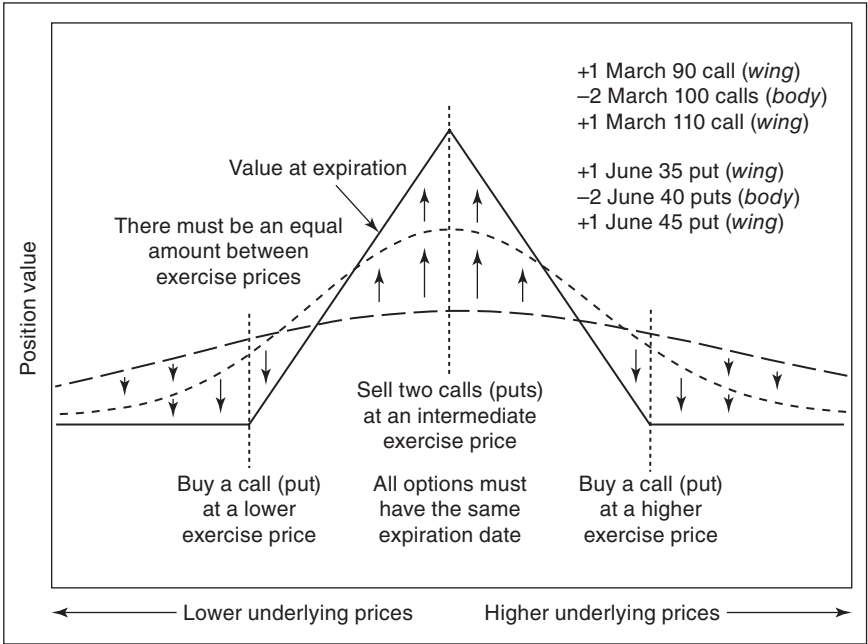
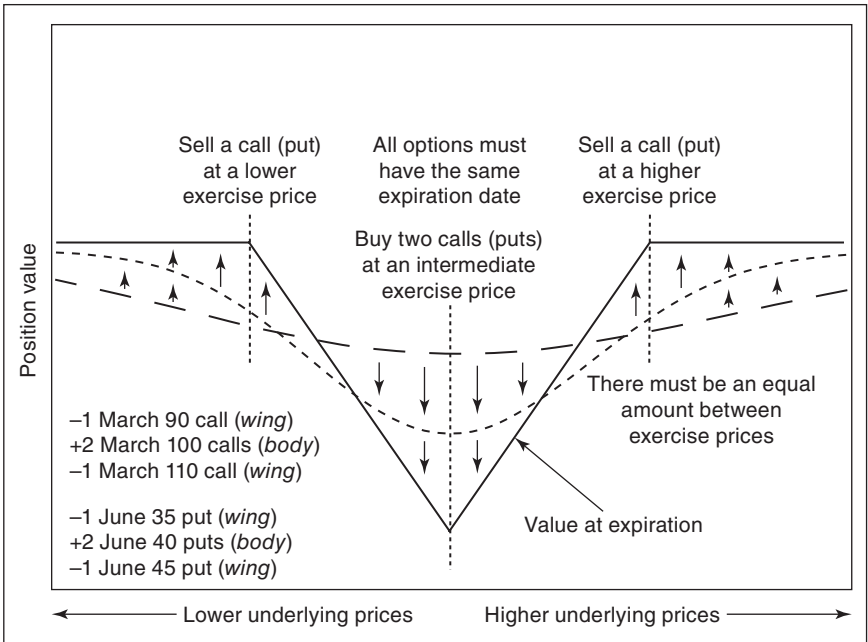


Figure 11-6 Short butterfly as time passes or volatility declines.



To understand these characteristics, let's consider the value of a long butterfly at expiration:

		Underlying Price at Expiration		
		80	100	120
+1 March 90 call	Position value	0	+10	+30
-2 March 100 calls	Position value	0	0	-20
+1 March 110 call	Position value	0	0	+10
Total		0	+10	0

If the underlying price is below 90 at expiration, all the calls will expire worthless, and the value of the position will be 0. If the underlying contract is above 120 at expiration, the combined value of the 90 and 110 calls will equal the value of the two 100 calls. Again, the value of the butterfly will be 0. Now suppose that the underlying contract is between 90 and 110 at expiration, specifically, right at the inside exercise price of 100. The 90 call will be worth 10.00, while the 100 and 110 calls will be worthless. The position will be worth exactly 10.00. If the underlying moves away from 100, the value of the butterfly will decline, but its value can never fall below 0. Summarizing, at expiration, a butterfly is worthless if the underlying contract is above or below the outside exercise prices (sometimes referred to as the *wings* of the butterfly). It has its maximum value at expiration when the underlying contract is right at the inside exercise price (sometimes referred to as the *body* of the butterfly). And the maximum value is always equal to the amount between exercise prices, in our example 10.00.

Because a butterfly at expiration always has a value between 0 and the amount between exercise prices, in our example, a trader should be willing to pay some amount between 0 and 10.00 for the position. The exact amount depends on the likelihood of the underlying contract finishing close to the inside price at expiration. If there is a high probability of this occurring, a trader might be willing to pay as much as 8.00 for the butterfly since it might very well expand to its full value of 10.00. If, however, there is a low probability of this occurring and, consequently, a high probability that the underlying contract will finish outside the extreme exercise prices, a trader may only be willing to pay 1.00 or 2.00 because he may very well lose his entire investment. This also explains why our example position is a *long* butterfly. Because the position can never be worth less than 0, a trader will always be required to pay some amount for the position. Otherwise, there would be a riskless profit opportunity. When a position requires an outlay of cash, a trader has bought, or is long, the position.

A butterfly will tend to be delta neutral when the inside exercise price is approximately at the money. Under these conditions, a long butterfly will tend to act like a short straddle, while a short butterfly will tend to act like a long straddle. With either a long butterfly or a short straddle, a trader wants the underlying market to sit still ($-\text{gamma}$, $+\text{theta}$) and implied volatility to fall ($-\text{vega}$). With either a short butterfly or a long straddle, a trader wants the underlying market to make a large move ($+\text{gamma}$, $-\text{theta}$) and implied volatility to rise ($+\text{vega}$). But there is one important difference. While a straddle is opened in terms of either profit potential or risk, a butterfly is strictly limited.

It can never be worth less than 0 nor more than the amount between exercise prices. This is important for a trader who might want to sell straddles but who is uncomfortable with the possibility of unlimited loss. Of course, there is always a risk-reward tradeoff. If a long butterfly has reduced risk when the trader is wrong, it will also have increased profit when the trader is right. For this reason, butterflies tend to be executed in much larger sizes than straddles. A trader may find that buying 300 butterflies ($300 \times 600 \times 300$) is actually less risky than selling 100 straddles. In option trading, size and risk do not always correlate. Some strategies done in large sizes can have a relatively small risk, while other strategies, even when done in small sizes, can have a relatively large risk. Risk depends not only on the size in which a strategy is executed but also on the characteristics of the strategy.

We know that a butterfly at expiration is worth its maximum when the underlying contract is right at the inside exercise price. If we assume that all options are European, with no possibility of early exercise, both a call and a put butterfly with the same exercise prices and the same expiration dates desire exactly the same outcome and therefore have identical characteristics. Both the March 90/100/110 call butterfly and the March 90/100/110 put butterfly will be worth a maximum of 10.00 with the underlying price exactly at 100 at expiration and a minimum of 0 with the underlying price below 90 or above 110. If both butterflies are not trading at the same price, there is a sure profit opportunity available by purchasing the cheaper and selling the more expensive.¹

Condor

Just as a butterfly can be thought of as a straddle with limited risk or reward, a *condor* can be thought of as a strangle with limited risk or reward. A condor consists of four options, two inside exercise prices (the body of the condor) and two outside exercise prices (the wings of the condor).² The ratio of a condor is always $1 \times 1 \times 1 \times 1$. Although the amount between the two inside exercise prices can vary, there must be an equal amount between the two lowest exercise prices and the two highest exercise prices. As with a butterfly, all options must expire at the same time and be of the same type (either all calls or all puts). In a long condor, the two outside exercise prices are purchased and the two inside exercise prices are sold, and vice versa for a short condor. Typical long and short condors are shown in Figures 11-7 and 11-8.

The value of a condor at expiration can never be less than 0 nor more than the amount between the two higher or the two lower exercise prices. A trader who buys a condor will pay some amount between these values, expecting that the underlying contract will finish between the two intermediate exercise prices, where the condor will be worth its maximum. A trader who sells a condor will take in some amount, expecting that the underlying contract will finish outside the extreme exercise prices, where the condor will be worthless.

¹ This is not necessarily true for butterflies consisting of American options, where early exercise is a possibility. A sure profit would exist only if one could be certain of carrying the position to expiration.

² Butterflies and condors fall under the general category of strategies known as wingspreads.

Figure 11-7 Long condor as time passes or volatility declines.

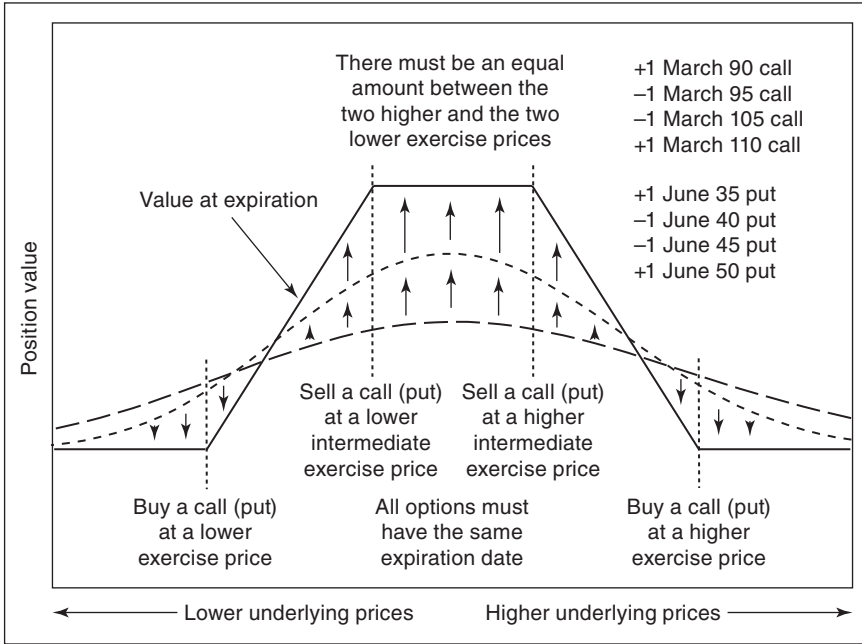
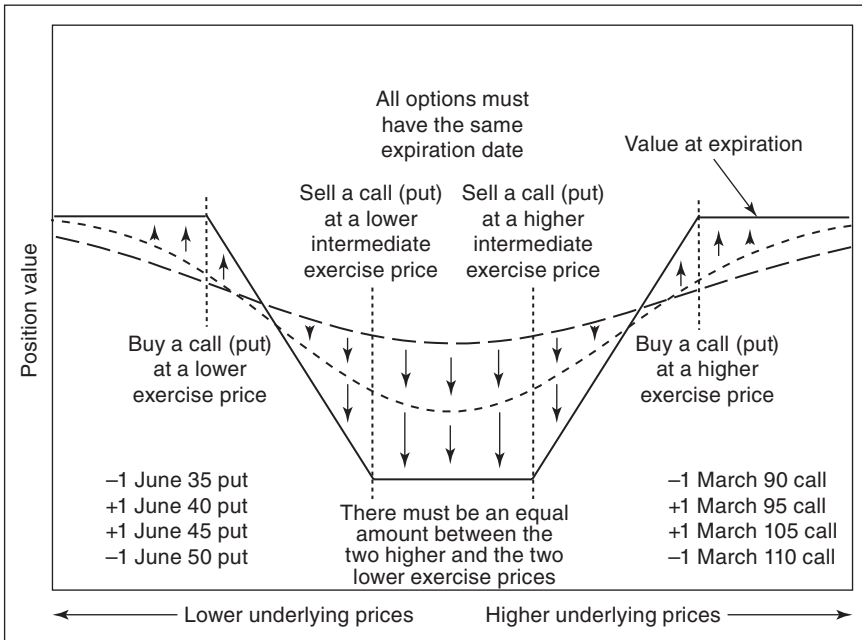


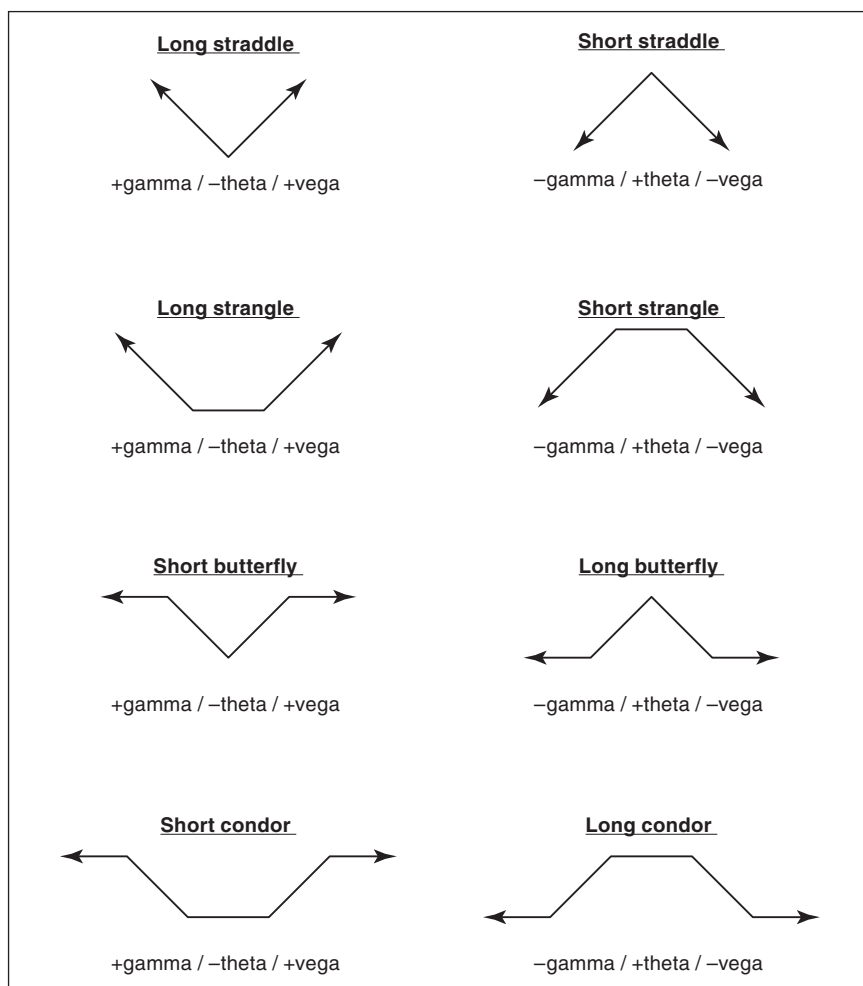
Figure 11-8 Short condor as time passes or volatility declines.



A condor will be approximately delta neutral when the underlying contract is midway between the two inside exercise prices. When all options are European, the value and characteristics of a call condor and put condor will be identical.

The four volatility spreads that we just described—straddles, strangles, butterflies, and condors—all have symmetrical P&L graphs. When executed delta neutral, as is most common, these strategies have no preference as to the direction of movement in the underlying market. Long straddles and strangles and short butterflies and condors prefer movement in the underlying market and an increase in implied volatility (+gamma, -theta, +vega). Short straddles and strangles and long butterflies and condors prefer no movement in the underlying market and a decline in implied volatility (-gamma, +theta, -vega). These characteristics are summarized in Figure 11-9.

Figure 11-9 Symmetrical strategies.



Ratio Spread

In a volatility spread, a trader need not be totally indifferent to the direction of movement in the underlying market. The trader may believe that movement in one direction is more likely than movement in the other direction. Given this, the trader may wish to construct a spread that either maximizes his profit or minimizes his loss when movement occurs in one direction rather than the other. In order to achieve this, a trader can construct a *ratio spread*—buying and selling unequal numbers of options where all options are the same type and expire at the same time. As with other volatility positions, the spread is typically delta neutral.

Consider the following delta-neutral position with the underlying contract trading at 100 (delta values are in parentheses):

Contract Position	Price per Contract
+3 October 105 call (25)	1.00
-1 October 95 call (75)	6.00

Now let's consider three possible prices for the underlying contract at expiration:

Underlying Price	95 Call P&L	105 Call P&L	Total P&L
80	+6.00 - 0 = +6.00	$3 \times (-1.00 + 0) = -3.00$	+3.00
120	+6.00 - 25.00 = -19.00	$3 \times (-1.00 + 15.00) = +42.00$	+23.00
100	+6.00 - 5.00 = +1.00	$3 \times (-1.00 + 0) = -3.00$	-2.00

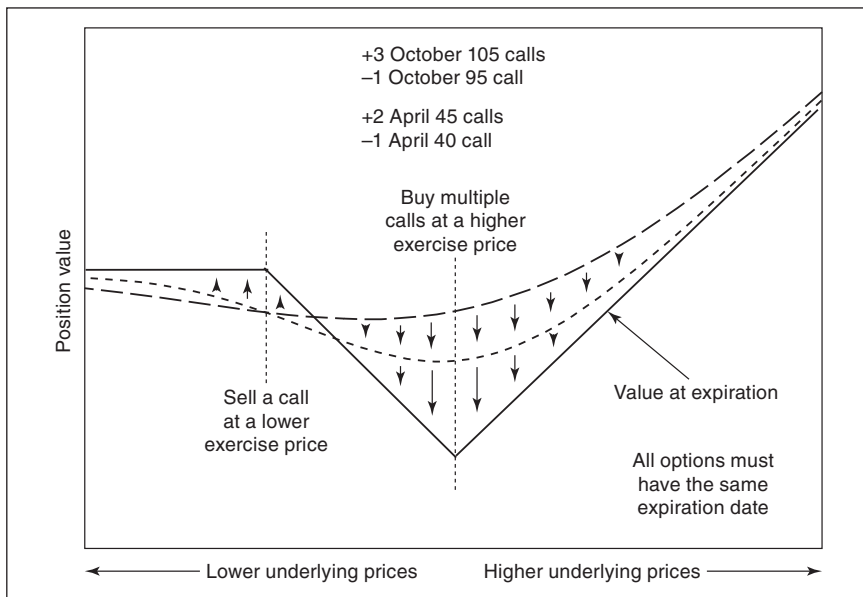
If the underlying contract makes a very big move in either direction, the position will show a profit. Of course, the profit will be much larger if the move is upward. If the underlying sits at 100 until expiration, the position will show a loss. This *call ratio spread*, where more calls are purchased than sold, wants movement in the underlying contract but clearly prefers upward movement, where the potential profit is unlimited. The P&L diagram for this type of strategy is shown in Figure 11-10.

The same type of position can be created using puts. A *put ratio spread*, where more puts are purchased than sold, also prefers movement in the underlying contract. But now there is a preference for downward movement because the profit potential on the downside will be unlimited. This is shown in Figure 11-11.

A ratio spread where more options are purchased than sold is sometimes referred to as *backspread*. Regardless of whether the spread consists of calls or puts, this type of spread always wants movement in the underlying market (+gamma, -theta) and/or an increase in implied volatility (+vega).

In a ratio spread where more options are purchased than sold, the spread will be worthless if the underlying contract makes a large enough downward move in the case of calls or a large enough upward move in the case of puts. For either spread to result in a profit, it must be executed initially for a credit, and this is a typical characteristic of these types of spreads. Indeed, under the assumptions of a traditional theoretical pricing model, a delta-neutral ratio spread where more options are purchased than sold should always result in a credit.

Figure 11-10 Call ratio spread (buy more than sell) as time passes or volatility declines.



Ratio spreads are often used to limit the risk in one direction. If we sell more calls than we buy, the spread will act like a short straddle ($-\gamma$, $+\theta$, $-\nu$) but with limited downside risk. If we sell more puts than we buy,

Figure 11-11 Put ratio spread (buy more than sell) as time passes or volatility declines.

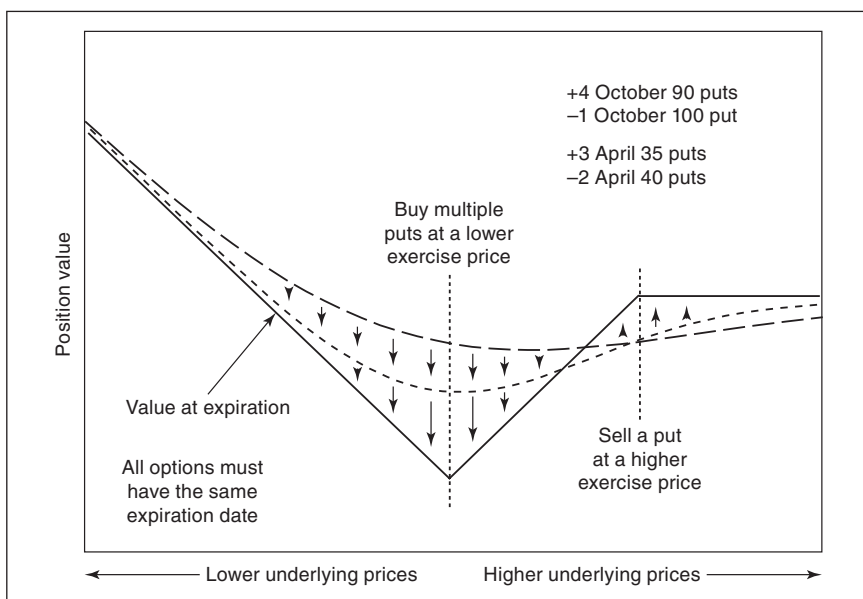
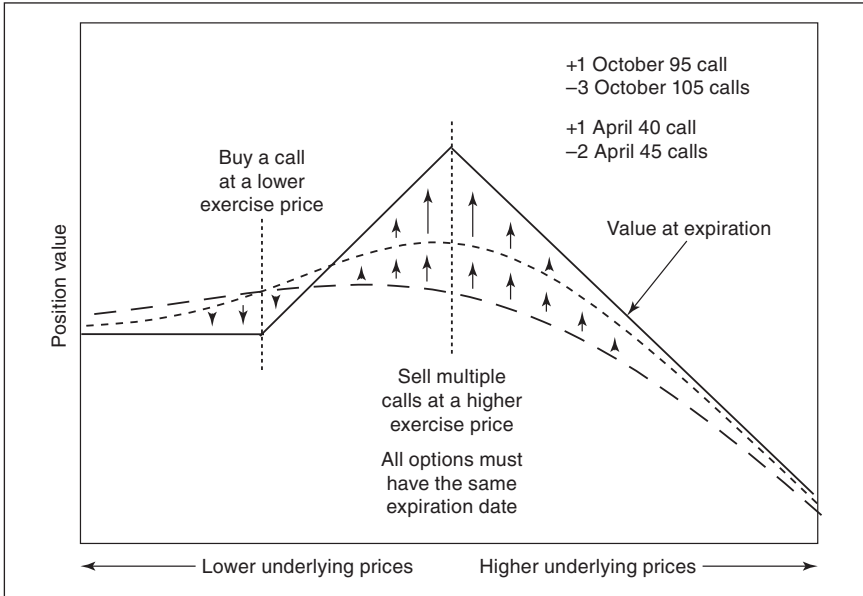
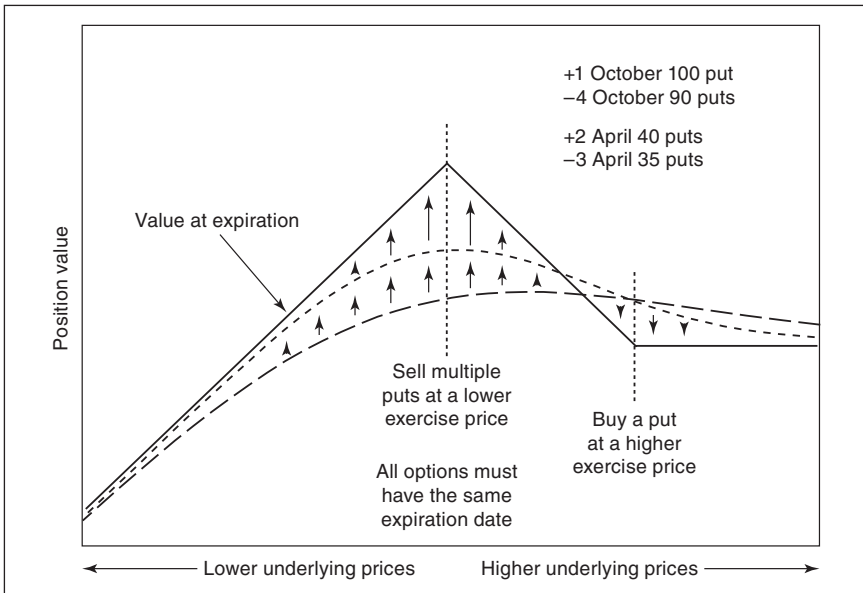


Figure 11-12 Call ratio spread (sell more than buy) as time passes or volatility declines.



the spread will have limited upside risk. The P&L diagrams for these types of spreads are shown Figures 11-12 and 11-13.

Figure 11-13 Put ratio spread (sell more than buy) as time passes or volatility declines.



A ratio spread where more options are sold than purchased is sometimes referred to as *frontspread*.³ Using calls, the position will be worthless at expiration if the underlying contract is below the lower exercise price. Using puts, the position will be worthless at expiration if the underlying contract is above the higher exercise price. The fact that the value of the position cannot fall below 0 limits the downside risk if more calls are sold than purchased and the upside risk if more puts are sold than purchased.

When executed as a single trade, ratio spreads are usually submitted using simple ratios, the most common being 2 to 1. However, other ratios—3 to 1, 4 to 1, or 3 to 2—are also relatively common.

Christmas Tree

Ratio spreads tend to mimic straddles, but with the risk or reward limited in one direction. We can also construct strategies that mimic strangles, but again with limited risk or reward in one direction. Such spreads are known as either *Christmas trees* or *ladders*.⁴

A call Christmas tree involves buying (selling) a call at a lower exercise price and selling (buying) one call each at two higher exercise prices. A put Christmas tree involves buying (selling) a put at a higher exercise price and selling (buying) one put each at two lower exercise prices. All options must be the same type and expire at the same time, with exercise prices most often chosen so that the entire position is delta neutral. When one option is bought and two options sold (a long Christmas tree), the position acts like a short strangle but with limited risk in one direction. When one option is sold and two options bought (a short Christmas tree), the position acts like a long strangle but with limited profit potential in one direction. P&L diagrams for typical Christmas trees are shown in Figures 11-14 through 11-17.

Although ratio spreads and Christmas trees have nonsymmetrical P&L graphs, their volatility characteristics tend to mimic straddles and strangles. A spread in which more options are purchased than sold will prefer movement in the underlying market and/or an increase in implied volatility (+gamma, -theta, +vega). A spread in which more options are sold than purchased will prefer no movement in the underlying market and/or a decline in implied volatility (-gamma, +theta, -vega). The characteristics of nonsymmetrical spreads are summarized in Figure 11-18.

Calendar Spread

If all options in a spread expire at the same time, the value of the spread at expiration depends solely on the underlying price. If, however, the spread consists of options that expire at different times, the spread's value depends not only on

³The terms *backspread* and *frontspread* date from the early days of option trading in the United States but are now used infrequently except by some older traders. Most traders simply refer to these strategies as ratio spreads, specifying whether more options are purchased or sold and the ratio of long to short options.

⁴The term *ladder* may also refer to a type of exotic option.

Figure 11-14 Long call Christmas tree as time passes or volatility declines.

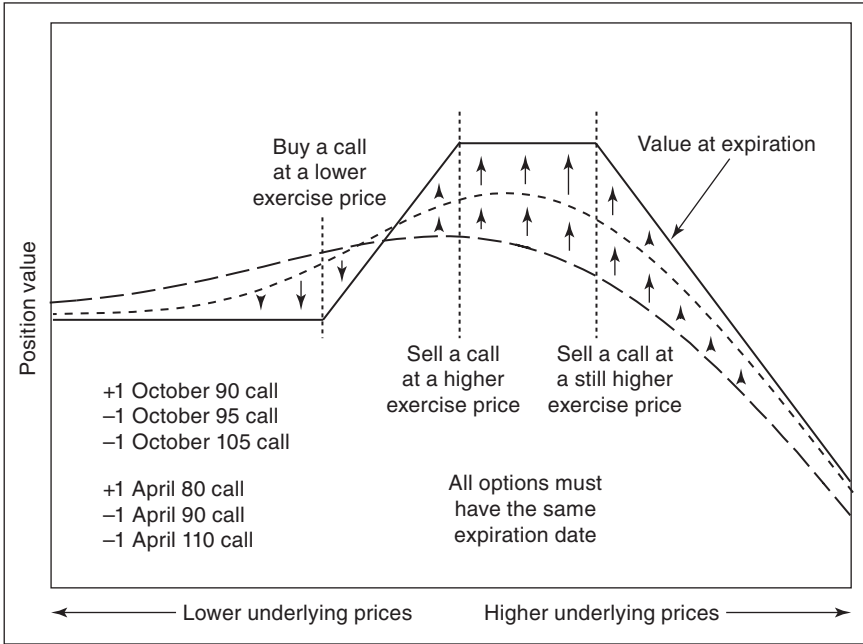


Figure 11-15 Short call Christmas tree as time passes or volatility declines.

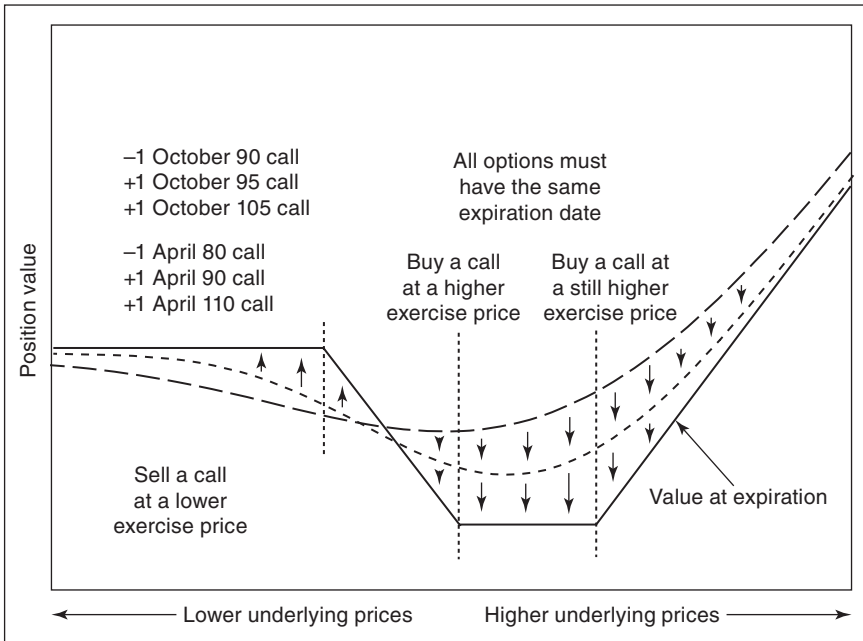


Figure 11-16 Long put Christmas tree as time passes or volatility declines.

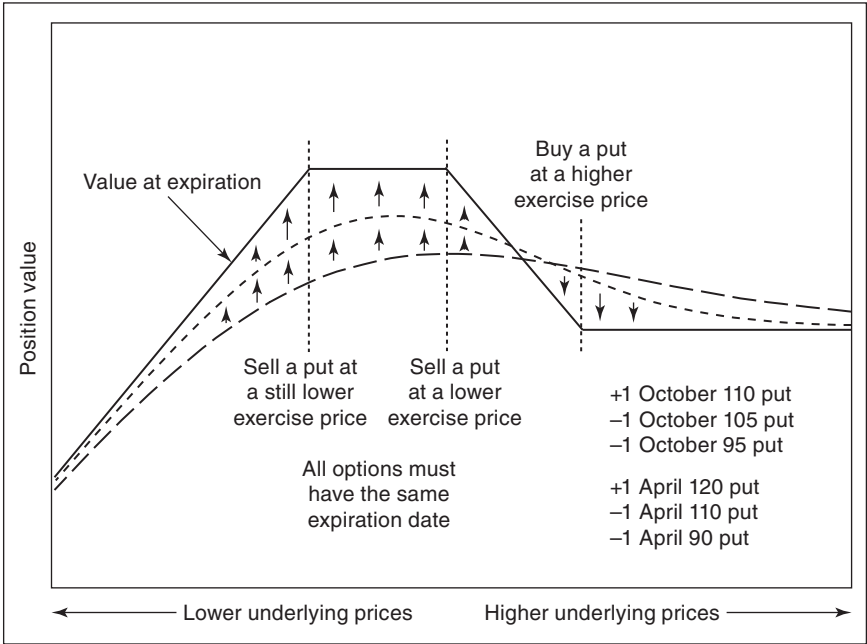


Figure 11-17 Short put Christmas tree as time passes or volatility declines.

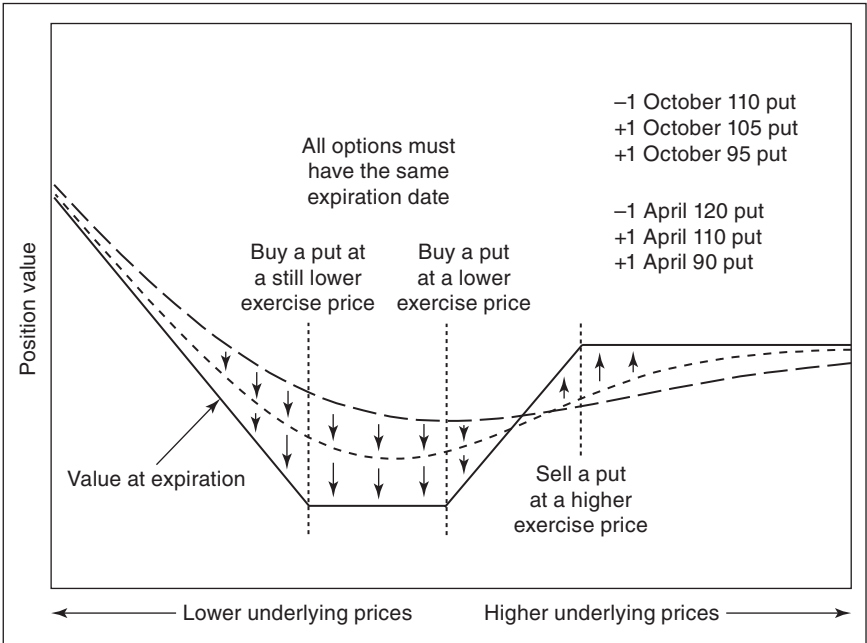
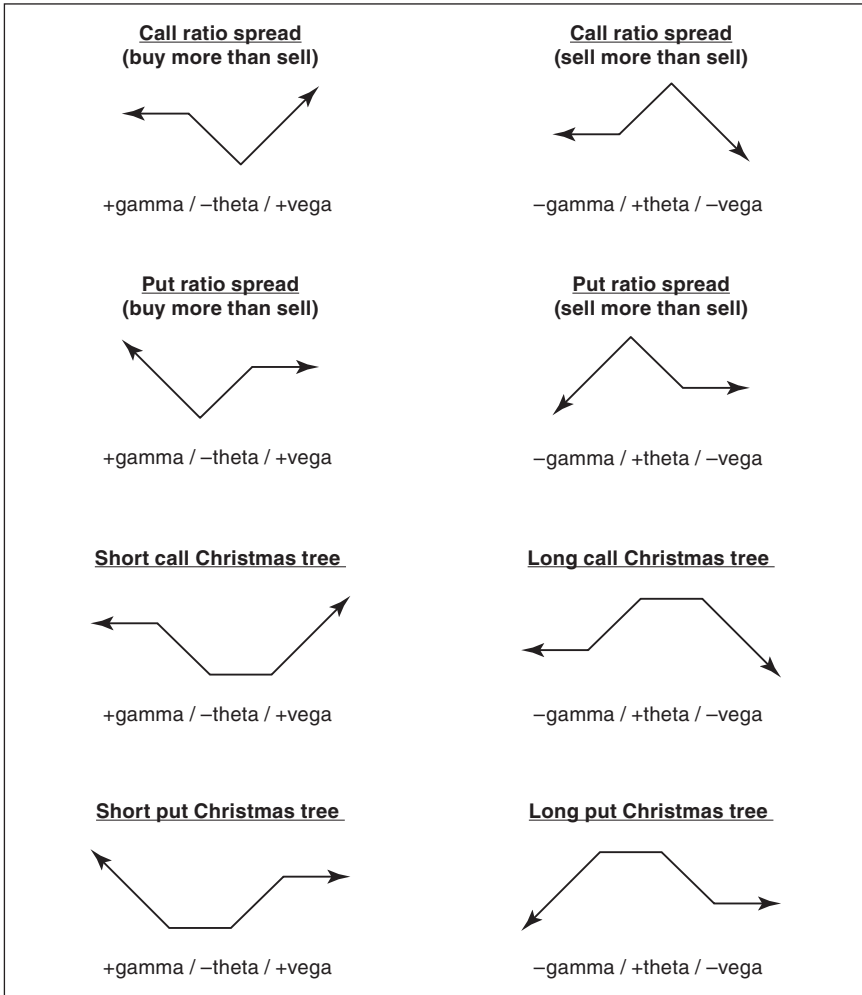


Figure 11-18 Nonsymmetrical strategies.



where the underlying market is when the short-term option expires but also on what will happen between that date and the date on which the long-term option expires. Calendar spreads, sometimes referred to as *time spreads* or *horizontal spreads*,⁵ consist of option positions that expire in different months.

The most common type of calendar spread consists of opposing positions in two options of the same type (either both calls or both puts) where both options have the same exercise price. When the long-term option is purchased and the short-term option is sold, a trader is long the calendar spread; when the short-term option is purchased and the long-term option is sold, the trader is short the calendar spread. Because a long-term option will typically be worth

⁵ In the early days of floor trading on option exchanges, expiration months were listed horizontally on the exchange display boards—hence the term *horizontal spread* for strategies consisting of options with different expiration months.

more than a short-term option, this is consistent with the practice of referring to any strategy that is executed at a debit as a long position and any spread that is executed for a credit as a short position.

Although calendar spreads are most commonly executed one to one (one contract purchased for each contract sold), a trader may ratio a calendar spread to reflect a bullish, bearish, or neutral market sentiment. For purposes of discussion, we will focus on one-to-one calendar spreads (one long-term option for each short-term option) that are approximately delta neutral. Because at-the-money options have delta values close to 50, the most common calendar spreads consist of long and short at-the-money options.⁶

The value of a calendar spread depends not only on movement in the underlying market but also on the marketplace's expectations about future market movement as reflected in the implied volatility. Because of this, a calendar spread has characteristics that differ from the other spreads we have discussed. If we assume that the options making up a calendar spread are approximately at the money, calendar spreads have two important characteristics:

1. A calendar spread will increase in value if time passes with no movement in the underlying contract.
2. A calendar spread will increase in value if implied volatility rises and decline in value if implied volatility falls.

Why should a calendar spread become more valuable as time passes? Consider the following spread, where the underlying contract, which is currently trading at 100, is the same for both options:

+1 June 100 call
-1 April 100 call

Suppose that there are four months remaining to June expiration and two months remaining to April expiration. If we assume a constant underlying price of 100 and a constant volatility of 20 percent, the value of the individual options as time passes, as well as the value of the spread, is shown in Figure 11-19.

The spread is initially worth 1.34, but as time passes, both options begin to decay. However the April option, with less time remaining to expiration, decays more rapidly than the June option. Over the first month, the April option loses 0.96, while the June option loses only 0.61. The spread has increased to 1.69.

Over the next month, with the underlying contract still at 100, the April option, because it is at the money, must give up its entire value of 2.30. The June option will also continue to decay, and at a slightly greater rate, losing 0.73. But the calendar spread has still increased to 3.26.

The increase in value of the calendar spread as time passes is the result of an important characteristic of theta that was noted in Chapter 8: as time to expiration grows shorter, the theta of an at-the-money option increases.

⁶To be more exact, at-the-forward options tend to have deltas closest to 50. For this reason, a trader might prefer a calendar spread that consists of at-the-forward options.

Figure 11-19 The value of a calendar spread as time passes.

Contract Month		Time to Expiration	
June	4 months	3 months	2 months
April	2 months	1 month	0
Option		Value	
June 100 call	4.60	3.99	3.26
April 100 call	3.26	2.30	0
Spread value	1.34	1.69	3.26

A short-term at-the-money option decays more rapidly than a long-term at-the-money option.

What will happen if the underlying contract does not sit still but instead makes a large upward or downward move? The value of a calendar spread depends on the long-term option retaining as much time value as possible while the short-term option decays. This will be true if both options remain at the money because an at-the-money option always has the greatest amount of time value. As an option moves either into the money or out of the money, its time value will disappear. A long-term option will always have greater time value than a short-term option. But, if the movement in the underlying contract is large enough and the option moves very deeply into the money or very far out of the money, even a long-term option will eventually lose almost all or its time value. This will cause the calendar spread to collapse, as shown in Figure 11-20.

Now let's consider the effect of changing volatility on a calendar spread. The value of the April/June 100 call calendar spread at different volatilities is shown in Figure 11-21.

As we raise or lower volatility, both options rise or fall in value, but the June option changes more quickly than the April option. We touched on this characteristic in Chapter 6, where we noted that a change in volatility will have a greater effect on a long-term option than on an equivalent short-term option. In other words, long-term options have greater vega values than short-term

Figure 11-20 The value of a calendar spread as the underlying price changes.

<i>Theoretical Value if the Underlying Price Is...</i>					
Option	80	90	100	110	120
June 100 call	0.10	1.07	4.60	11.39	20.31
April 100 call	0.01	0.36	3.26	10.51	20.04
Spread value	0.09	0.71	1.34	0.88	0.27

Figure 11-21 The value of a calendar spread as volatility changes.

<i>Theoretical Value if Volatility Is . . .</i>					
Option	10 percent	15 percent	20 percent	25 percent	30 percent
June 100 call	2.30	3.45	4.60	5.75	6.90
April 100 call	1.63	2.44	3.26	4.07	4.88
Spread value	0.67	1.01	1.34	1.68	2.02

options. This difference in sensitivity to a change in volatility causes the calendar spread to widen if we increase volatility and to narrow if we reduce volatility.

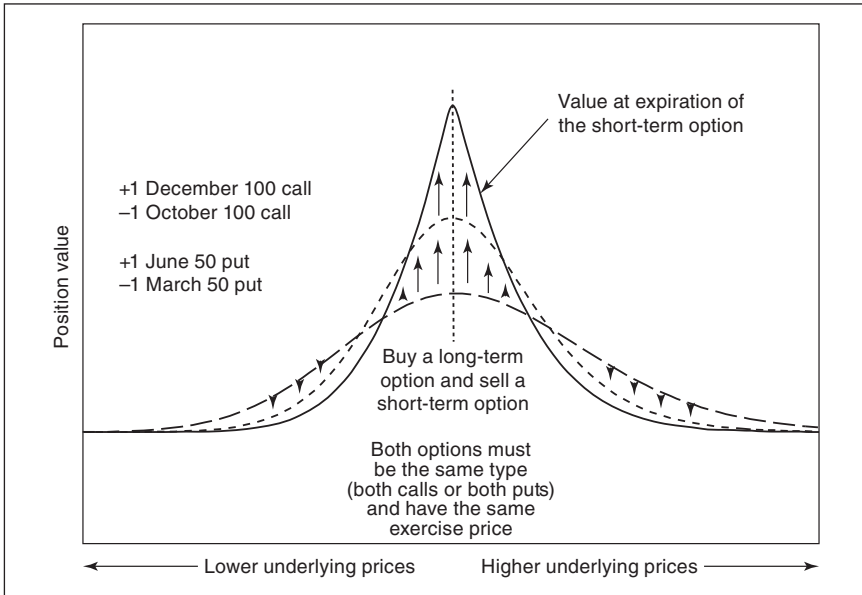
A trader who is long a calendar spread wants two apparently contradictory conditions in the marketplace. First, he wants the underlying contract to sit still in order to take advantage of the greater time decay for the short-term option. Second, he wants everyone to think that the market is going to move so that implied volatility will rise, causing the long-term option to rise in price more quickly than the short-term option. Can this happen? Can the market remain unchanged yet everyone think that it will move? In fact, it happens quite often because events that do not have an immediate effect on the underlying contract may be perceived to have a future effect on the underlying.

The most common example occurs when news is pending that is likely to affect the underlying contract but whose exact effect is unknown. Consider a company that announces that its CEO will make an important statement one week from today. If no one knows the content of the statement, there is unlikely to be any significant change in the company's stock price prior to the statement. But traders will assume that the statement, when it is made, will have an effect, perhaps a dramatic one, on the stock price. The possibility of future movement in the stock price will cause implied volatility to rise. This combination of conditions—the lack of movement in the underlying stock together with rising implied volatility—will cause calendar spreads to widen.

Of course, the assumption of future stock movement as a result of the CEO's statement is just that—an assumption. If the statement turns out to be irrelevant to the company's fortunes (the CEO wanted to announce that he and his wife just became grandparents), any presumption of future volatility is removed. The result will be a decline in implied volatility, causing calendar spreads to narrow.

The effect of implied volatility is what distinguishes time spreads from the other types of spreads we have discussed. Long straddles, long strangles, and short butterflies all want the volatility of the underlying contract as well as implied volatility to rise (+gamma, +vega). Short straddles, short strangles, and long butterflies all want the volatility of the underlying contract as well as implied volatility to fall (–gamma, –vega). But with calendar spreads underlying volatility and implied volatility have opposite effects. A quiet market or an increase in implied volatility will help a long calendar spread (–gamma, +vega), while a big move in the underlying market or a decline in implied volatility will

Figure 11-22 Long calendar spread as time passes.



help a short calendar spread (+gamma, -vega). This opposite effect is what gives calendar spreads their unique characteristics.

Figures 11-22 and 11-23 show the value of long and short calendar spreads as time passes. Figures 11-24 and 11-25 show the value as volatility changes.

Figure 11-23 Short calendar spread as time passes.

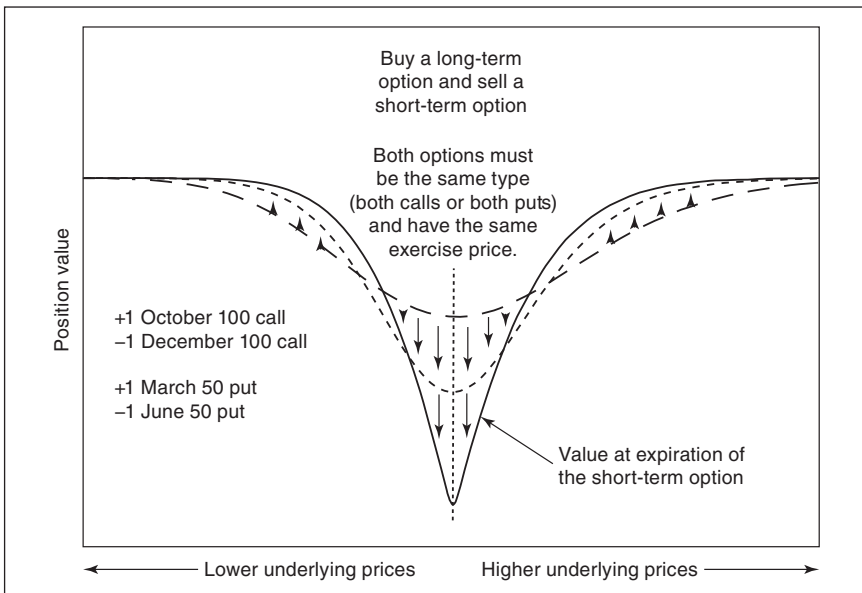
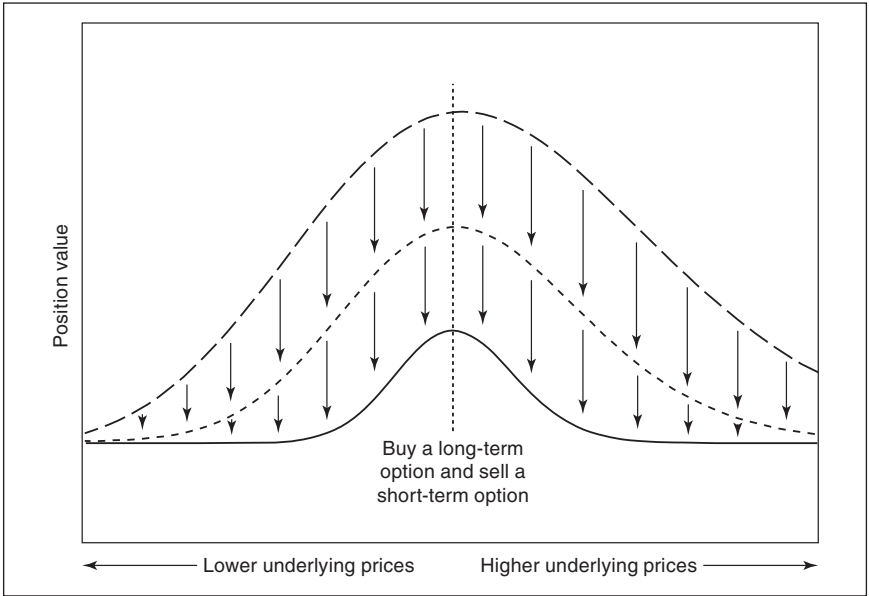
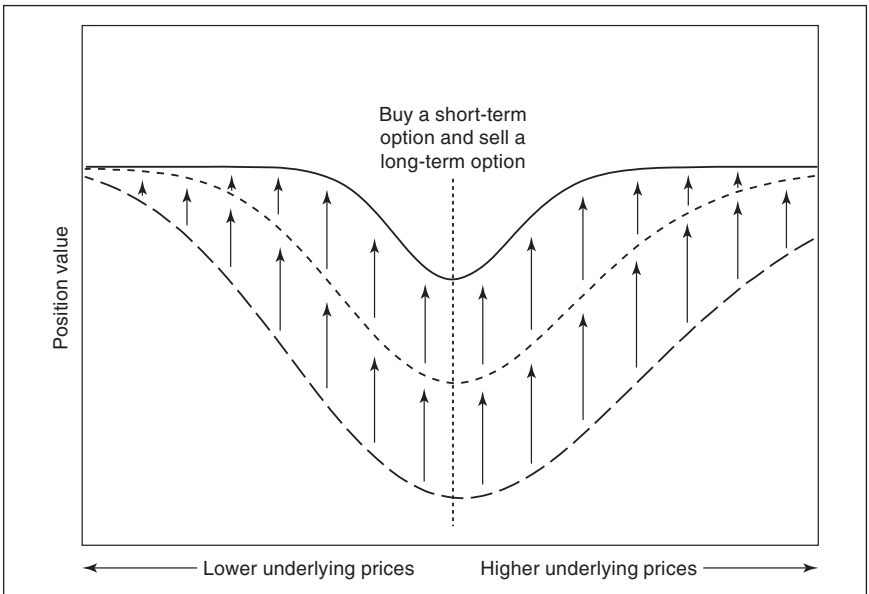


Figure 11-24 Long calendar spread as volatility declines.



Although the effects of time and volatility apply to calendar spreads in all markets, there may be other considerations, depending on the specific underlying market. In the foregoing examples, we assumed that the underlying contract for both the short- and long-term option was the same. In the stock option

Figure 11-25 Short calendar spread as volatility declines.



market, this will always be true. The underlying contract for General Electric (GE) options, regardless of the expiration month, is always GE stock. And GE stock can only have a single price at any one time. But in a futures market the underlying for a futures option is a specific futures contract, and different option expirations can have different underlying futures contracts.

Consider a futures market where there are four futures months: March, June, September, and December. If serial months are available, an April/June calendar spread will have the same underlying contract, June futures. But a March/June calendar spread will have one underlying contract for March options, a March future, and a different underlying contract for June options, a June future. Although one might expect March futures and June futures to move together, there is no guarantee that they will. Particularly in commodity markets, short-term supply and demand considerations can cause futures contracts on the same commodity to move in different directions. In addition to volatility considerations, a trader who buys a June/March call calendar spread must also consider the possibility that March futures will rise relative to June futures.

In order to offset the risk of futures contracts moving against a calendar-spread position, it is common in commodity futures markets for a trader to offset a calendar spread with an opposing position in the futures market. In our example, if a trader buys the March/June call calendar spread, he can offset the position by purchasing March futures and selling June futures.

How many futures spreads should the trader execute? If he wants a position that is sensitive only to volatility, he ought to trade the number of futures spreads required to be delta neutral. If both calls are at the money, with deltas of approximately 50, a trader who buys 10 call calendar spreads (buy 10 June calls, sell 10 March calls) will be long 500 deltas in June and short 500 deltas in March. Therefore, he should buy 5 March futures contracts and sell 5 June futures contracts. The entire position will be (delta values are in parentheses)

$$\begin{aligned} &+10 \text{ June calls } (+500), - \text{ June futures } (-500) \\ &-10 \text{ March calls } (-500), +5 \text{ March futures } (+500) \end{aligned}$$

This type of balancing is not necessary—indeed, not possible—in stock options because the underlying for all months is identical.

Time Butterfly

In futures markets, as opposed to option markets, a butterfly is a position in three futures months. A trader will buy (sell) one each of a short- and long-term futures contract and sell (buy) two intermediate-term futures contracts. A similar type of strategy can be done in option markets. A traditional option butterfly consists of options at three different exercise prices but with the same expiration date. A time butterfly (sometimes shortened to *time fly*) consists of options at the same exercise price but with three different expiration dates. All options must be the same type (either all calls or all puts), with approximately the same amount of time between expirations. The outside expiration months

are usually referred to as the *wings* and the inside expiration month as the *body*. Some typical time butterflies might be

+1 May 100 call (wing)	-1 January 50 put (wing)
-2 June 100 calls (body)	+2 March 50 puts (body)
+1 July 100 call (wing)	-1 May 50 put (wing)
-1 March 70 call (wing)	+1 February 25 put (wing)
+2 June 70 calls (body)	-2 June 25 puts (body)
-1 September 70 call (wing)	+1 October 25 put (wing)

Note that a time butterfly consists of simultaneously buying or selling a long-term calendar spread and taking an opposing position in a short-term calendar spread, where each spread has one common expiration month. The example May/June/July 100 call time butterfly consists of buying the May 100 call and selling the June 100 call (selling the May/June calendar spread) and simultaneously selling the June 100 call and buying the July 100 call (buying the June/July calendar spread).

If all options remain at the money, as time passes, the value of a calendar spread will increase. The short-term spread must therefore be worth more than the long-term spread. Consequently, if we buy the short-term calendar spread and sell the long-term calendar spread (buying the body and selling the wings), in total, we will pay more than we receive. Because the entire position will result in a debit, we are *long* the time butterfly. If we do the opposite, selling the short-term calendar spread and buying the long-term spread (selling the body and buying the wings), we are *short* the time butterfly.⁷ This can be somewhat confusing because in a traditional butterfly consisting of different exercise prices, the combination of buying the wings and selling the body results in a debit. But in a time butterfly consisting of different expiration months, buying the wings and selling the body results in a credit.

The value of a long time butterfly as time passes and as volatility falls is shown in Figures 11-26 and 11-27. The value of the spread will tend to collapse as the underlying contract moves away from the exercise price, implying that the spread has a negative gamma. Consequently, the spread must also have a positive theta. Finally, the value of the spread falls as volatility declines, implying that the spread has a positive vega. In sum, a long time butterfly has characteristics similar to those of a long calendar spread.

Effect of Changing Interest Rates and Dividends

Thus far we have considered only the effects of changes in underlying price, time, and volatility on the value of a volatility spread. What about changes in interest rates and, in the case of stocks, dividends?

⁷We are making the assumption here that the implied volatility of all expirations is the same. If the implied volatility differs across expiration months, a long time butterfly might in fact result in a credit.

Figure 11-26 Long time butterfly as time passes.

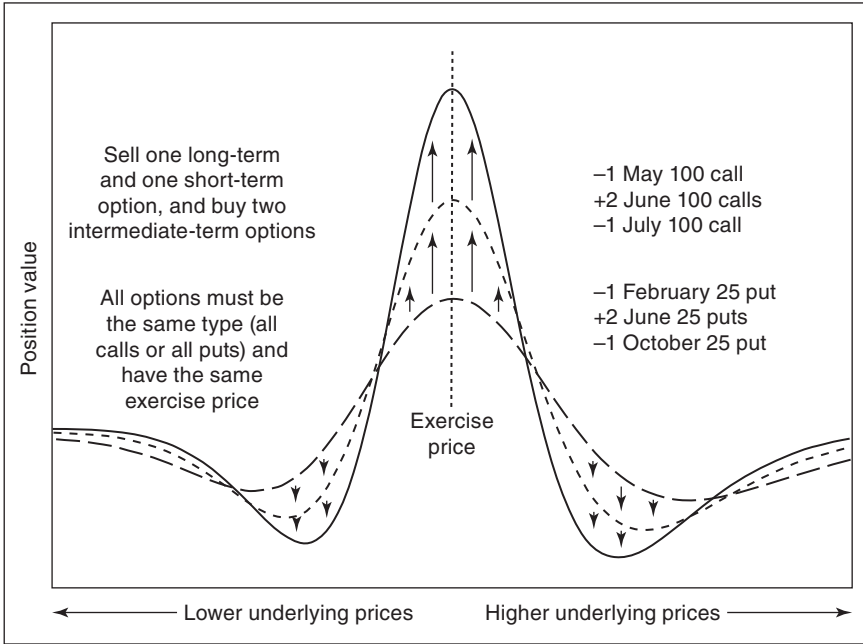
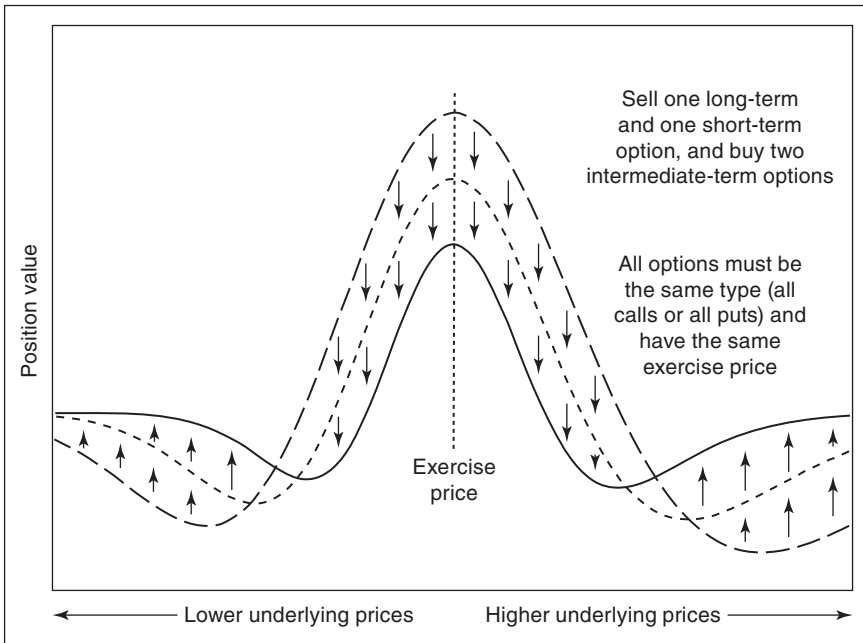


Figure 11-27 Long time butterfly as volatility declines.



Because there is no carrying cost associated with the purchase or sale of a futures contract, interest rates have only a minor impact on futures options and, consequently, a relatively minor effect on the value of all futures option volatility spreads.⁸ However, in a stock option market, a change in interest rates will cause the forward price of stocks to change. If all options in a spread expire at the same time, the change in forward price is likely to affect all options equally, causing only small changes in the value of the spread. However, if we have a stock option position involving two different expiration dates, we must consider two different forward prices. And these two forward prices may not be equally sensitive to a change in interest rates.

Consider the following situation:

$$\text{Stock price} = 100 \quad \text{interest rate} = 8.00\% \quad \text{dividend} = 0$$

Suppose that a trader buys a call calendar spread:

$$\begin{aligned} &+10 \text{ June } 100 \text{ calls} \\ &-10 \text{ March } 100 \text{ calls} \end{aligned}$$

If there are three months remaining to March expiration and six months remaining to June expiration, the forward prices for March stock and June stock are 102.00 and 104.00, respectively. If interest rates rise to 10 percent, the forward price for March will be 102.50 and the forward price for June will be 105. With more time remaining to June expiration, the June forward price is more sensitive to a change in interest rates. Assuming that the deltas of both options are approximately equal, the June option will be more affected by the increase in interest rates than the March option, and the calendar spread will expand. In the same way, if interest rates decline, the calendar spread will narrow because the June forward price will fall more quickly than the March forward price. A long call calendar spread in the stock option market must therefore have a positive rho, and a short call calendar spread must have a negative rho.

Changes in interest rates have the opposite effect on stock option puts. In our example, if interest rates rise from 8 to 10 percent, the June forward price will rise more than the March forward price. If we assume, again, that the deltas of both options are approximately equal, and recalling that puts have negative deltas, the June put will show a greater decline in value than the March put. The put calendar spread will therefore narrow. In the same way, if interest rates decline, the put calendar spread will expand. A long put calendar spread in the stock option market must therefore have a negative rho, and a short put calendar spread must have a positive rho.

The degree to which stock option calendar spreads are affected by changes in interest rates depends primarily on the amount of time between expirations. If there are six months between expirations (e.g., March/September), the effect will be much greater than if there is only one month between expirations (e.g., March/April).

⁸Interest rates can, of course, affect the relative value of different futures months. As noted, we can offset this risk by trading a futures spread along with the futures option calendar spread.

Changes in dividends can also affect the value of stock option calendar spreads because it may change the forward price of the stock. Dividends, however, have the opposite effect on stock options as changes in interest rates. An increase in the dividend lowers the forward price of stock, while a cut in the dividend raises the forward price. If all options expire at the same time, the change in the forward price for the stock will have an equal effect on all options, and the change in the value of a spread will be negligible. But in a calendar spread, if at least one dividend payment is expected between the expiration dates, an increase in dividends will cause a call calendar spread to narrow and put calendar spread to expand. A decrease in dividends will have the opposite effect, causing a call calendar spread to widen and a put calendar spread to narrow. Even though there is no Greek letter associated with dividend risk, we might say that a call calendar spread has negative dividend risk (its value falls as dividends rise) and a put calendar spread has positive dividend risk (its value rises as dividends rise). Examples of the effects of changing interest rates and dividends on stock option calendar spreads are shown in Figure 11-28.

In Figure 11-28, we can see that an increase in interest rates will reduce the value of a put calendar spread and an increase in dividends will reduce the value of a call calendar spread. Indeed, if we raise interest rates high enough, the put calendar spread can take on a negative value, with the long-term put having a lower value than the short-term put. The same will be true for a call calendar spread if we increase dividends enough. If a stock pays no dividends, the value of a call calendar spread should always have some value greater than 0. Even if volatility is very low, the spread should still be worth a minimum of the cost of carry on the stock between expiration months. This is only true, however, if a trader can carry a short stock position between expiration months. If a situation arises where no stock can be borrowed, the trader who owns a call calendar spread may be forced to exercise his long-term option, thereby losing the time value associated with the option. This is sometimes referred to as a *short squeeze*.

Figure 11-28 Effect of changing interest rates and changing dividends on stock option calendar spreads.

Stock price = 100 Volatility = 20% Dividend = 0 Time to March expiration = 3 months Time to June expiration = 6 months					
If the interest rate is...	0 percent	3 percent	6 percent	9 percent	12 percent
June 100 call	5.64	6.37	7.16	7.99	8.87
March 100 call	3.99	4.36	4.75	5.16	5.58
Call spread value	1.65	2.01	2.41	2.83	3.29
June 100 put	5.64	4.88	4.20	3.59	3.05
March 100 put	3.99	3.61	3.26	2.93	2.63
Put spread value	1.65	1.27	0.94	0.66	0.42

(continued)

Figure 11-28 (continued)

Stock price = 100 Volatility = 20% Interest rate = 6.00%					
Time to March expiration = 3 months					
Time to June expiration = 6 months					
If quarterly dividend is...	0	0.50	1.00	1.50	2.00
June 100 call	7.16	6.57	6.00	5.47	4.96
March 100 call	4.75	4.46	4.19	3.93	3.68
Call spread value	2.41	2.11	1.81	1.54	1.28
June 100 put	4.20	4.60	5.02	5.47	5.95
March 100 put	3.26	3.47	3.70	3.93	4.17
Put spread value	0.94	1.13	1.32	1.54	1.78

Diagonal Spreads

A *diagonal spread* is similar to a calendar spread except that the options have different exercise prices. Although many diagonal spreads are executed one to one (one long-term option for each short-term option), diagonal spreads can also be ratioed, with unequal numbers of long and short market contracts. With the large number of variations in diagonal spreads, it is almost impossible to generalize about their characteristics. Each diagonal spread must be analyzed separately to determine the risks and rewards associated with the spread.

There is, however, one type of diagonal spread about which we can generalize. If a diagonal spread is done one to one and both options are of the same type and have approximately the same delta, the diagonal spread will act very much like a conventional calendar spread. Examples of this type of diagonal spread are shown in Figure 11-29 (delta values are in parentheses).

Even though there are many different volatility spreads, traders tend to classify spreads in terms of their basic volatility characteristics. While some volatility spreads may prefer movement in one direction rather than the other, a

Figure 11-29 Diagonal spreads.

Time to June expiration = 4 months	
Time to April expiration = 2 months	
Underlying price = 100	
Volatility = 30%	
+1 June 115 call	2.20 (23)
-1 April 110 call	1.60 (23)
+1 June 80 put	0.72 (-8)
-1 April 85 put	0.48 (-8)

trader who initiates a volatility spread is concerned primarily with the magnitude of movement in the underlying contract and only secondarily with the direction of movement. Therefore, all volatility spreads tend to be approximately delta neutral. If a trader has a large positive or negative delta such that directional considerations become more important than volatility considerations, the position can no longer be considered a volatility spread.

All spreads that are helped by movement in the underlying market have a positive gamma. All spreads that are hurt by movement in the underlying market have a negative gamma. A trader who has a positive gamma position is said to be *long premium* and is hoping for a volatile market with large moves in the underlying contract. A trader who has a negative gamma is said to be *short premium* and is hoping for a quiet market with only small moves in the underlying market.

Because the effect of market movement and the effect of time decay always work in opposite directions, any spread with a positive gamma will necessarily have a negative theta, and any spread with a negative gamma will necessarily have a positive theta. If market movement helps, the passage of time hurts, and if market movement hurts, the passage of time helps. An option trader cannot have it both ways.

Finally, spreads that are helped by rising volatility have a positive vega. Spreads that are helped by falling volatility have a negative vega. In theory, the vega refers to the sensitivity of a theoretical value to a change in the volatility of the underlying contract over the life of the option. In practice, however, traders associate the vega with the sensitivity of an option's price to a change in implied volatility. Spreads with a positive vega will be helped by any increase in implied volatility and hurt by any decline; spreads with a negative vega will be helped by any decline in implied volatility and hurt by any increase. The delta, gamma, theta, and vega characteristics of the primary types of volatility spreads are summarized in Figure 11-30.

Because volatility spreads tend to be delta neutral and the theta and gamma are always of opposite sign, we can place volatility spreads into one of four categories depending on the effect of movement in the underlying contract (positive or negative gamma) and the effect of changes in implied volatility (positive or negative vega):

Gamma	Vega	Conditions that Will Help the Position
+	+	More volatile underlying contract; rising implied volatility
-	-	Less volatile underlying contract; falling implied volatility
+	-	More volatile underlying contract; falling implied volatility
-	+	Less volatile underlying contract; rising implied volatility

Of course, within each of these categories, some spreads will have larger gamma or vega values and some spreads will have smaller values. Of these, straddles and strangles tend to have the largest gamma and vega values and therefore the greatest risk. They will result in the greatest profit when the trader is correct in his assessment of market conditions, but they will result in the

Figure 11-30 Summary of common volatility spreads.

Spread	Delta*	Gamma	Theta	Vega	Downside Risk/Reward	Upside Risk/Reward
Long straddle	0	+	-	+	Unlimited reward	Unlimited reward
Long strangle	0	+	-	+	Unlimited reward	Unlimited reward
Short butterfly	0	+	-	+	Limited reward	Limited reward
Short condor	0	+	-	+	Limited reward	Limited reward
Call ratio spread (buy more than sell)	0	+	-	+	Limited reward [†]	Unlimited reward [†]
Put ratio spread (buy more than sell)	0	+	-	+	Unlimited reward [†]	Limited reward [†]
Short straddle	0	-	+	-	Unlimited risk	Unlimited risk
Short strangle	0	-	+	-	Unlimited risk	Unlimited risk
Long butterfly	0	-	+	-	Limited risk	Limited risk
Long condor	0	-	+	-	Limited risk	Limited risk
Call ratio spread (sell more than buy)	0	-	+	-	Limited risk [†]	Unlimited risk [†]
Put ratio spread (sell more than buy)	0	-	+	-	Unlimited risk [†]	Limited risk [†]
Long calendar spread	0	-	+	+	Limited risk	Limited risk
Short calendar spread	0	+	-	-	Limited reward	Limited reward

*We assume that initially all spreads are approximately delta neutral.
[†]We refer here to the great majority of delta-neutral ratio spreads, which result in a credit when buying more than selling and which result in a debit when selling more than buying.

greatest loss when the trader is wrong. Butterflies and condors are at the other end of the spectrum. These spreads yield smaller profits when the trader is right but also result in smaller losses when the trader is wrong. Ratio spreads and Christmas trees fall somewhere in between.

Volatility spreads can be further distinguished by their limited or unlimited risk-reward characteristics, both on the upside and on the downside. These characteristics are also summarized in Figure 11-30.

Figure 11-31 is an evaluation table with the theoretical value, delta, gamma, theta, vega, and rho of several different options. Following this table are examples of volatility spreads of the types discussed in this chapter, along with their total delta, gamma, theta, vega, and rho. (Although the examples in Figure 11-31 assume that the underlying is stock, except for the rho, the characteristics of each type of spread will tend to be the same for options on futures.) The reader will see that each spread does indeed have the positive or negative sensitivities summarized in Figure 11-30. Note also that a volatility spread need not be exactly delta neutral. (Indeed, as we saw in Chapter 7, no trader can say with absolute certainty whether a position is really delta neutral.) In practice, a volatility spread should have a delta that is small enough that the directional considerations are less important than the volatility considerations. This is often a subjective judgment.

Also included in Figure 11-31 is the theoretical value of each spread. This is simply the cash flow that results if each spread is executed at theoretical value. Purchases of options result in a cash debit (indicated with a negative sign), and sales represent a cash credit (indicated with a positive sign). In common terminology, a trader is said to be long the spread if it results in a cash debit and short the spread if it results in a cash credit.

Note that no price is given for any of the option contracts in Figure 11-31, and therefore, no theoretical edge can be calculated for any of the spreads. The prices at which a spread is executed may be good or bad, resulting in a positive or negative theoretical edge. But, once the spread has been established, the market conditions that will help or hurt the spread are determined by its characteristics, not by the initial prices. Like all traders, an option trader must not let his previous trading activity affect his current judgment. A trader's primary concern should not be what happened yesterday but what can be done today to make the most of the current situation, whether attempting to maximize a potential profit or minimize a potential loss.

Choosing an Appropriate Strategy

With so many spreads available, how can we decide which type of spread is best? First and foremost, we will want to choose spreads that have a positive theoretical edge to ensure that if we are right about market conditions, we have a reasonable expectation of showing a profit. Ideally, we want to construct a spread by purchasing options that are underpriced (too cheap) and selling options that are overpriced (too expensive). If we can do this, the resulting spread, whatever its type, will always have a positive theoretical edge.

More often, however, our opinion about volatility will result in all options appearing either overpriced or underpriced. When this happens, it will be impossible to both buy and sell options at advantageous prices. Such a market can be easily identified by comparing our volatility estimate with the implied volatility in the option marketplace. If implied volatility is lower than the volatility estimate, options will be underpriced. If implied volatility is higher than our estimate, options will be overpriced. This leads to the following principle:

If implied volatility is low, such that options generally appear underpriced, look for spreads with a positive vega. If implied volatility is high, such that options generally appear overpriced, look for spreads with a negative vega.

The theoretical values and deltas in Figure 11-31 have been reproduced in Figures 11-32 and 11-33, but now prices have been included, reflecting implied volatilities that differ from the volatility input of 20 percent. The prices in Figure 11-32 reflect an implied volatility of 17 percent. In this case, only spreads with a positive vega will have a positive theoretical edge:

- Long straddles and strangles
- Short butterflies and condors
- Ratio spreads—long more than short (including short Christmas trees)
- Long calendar spreads

The prices in Figure 11-33 reflect an implied volatility of 23 percent. Now only spreads with a negative vega will have a positive theoretical edge:

- Short straddles and strangles
- Long butterflies and condors
- Ratio spreads—short more than long (including long Christmas trees)
- Short calendar spreads

Figure 11-31 Examples of common volatility spreads.

Stock price = 100		Time to April expiration = 2 months		Volatility = 20%		Interest rate = 6.00%		Dividend = 0				
<i>Calls</i>							<i>Puts</i>					
Exercise Price	Theoretical Value	Delta	Gamma	Theta	Vega	Rho	Theoretical Value	Delta	Gamma	Theta	Vega	Rho
April 90	11.17	93	1.7	-0.023	0.06	0.136	.27	-7	1.7	-0.008	0.06	-0.013
April 95	6.98	79	3.6	-0.031	0.12	0.119	1.04	-21	3.6	-0.016	0.12	-0.037
April 100	3.76	56	4.8	-0.035	0.16	0.088	2.77	-44	4.8	-0.019	0.16	-0.077
April 105	1.71	33	4.4	-0.030	0.15	0.052	5.67	-67	4.4	-0.013	0.15	-0.121
April 110	0.65	16	3.0	-0.019	0.10	0.025	9.56*	-84	3.0	-0.001	0.10	-0.156
Stock price = 100		Time to June expiration = 4 months		Volatility = 20%		Interest rate = 6.00%		Dividend = 0				
<i>Calls</i>							<i>Puts</i>					
Exercise Price	Theoretical Value	Delta	Gamma	Theta	Vega	Rho	Theoretical Value	Delta	Gamma	Theta	Vega	Rho
June 90	12.55	87	1.8	-0.022	0.12	0.249	.76	-13	1.8	-0.008	0.12	-0.045
June 95	8.71	75	2.8	-0.026	0.18	0.221	1.83	-25	2.8	-0.011	0.18	-0.089
June 100	5.62	59	3.4	-0.027	0.22	0.178	3.64	-41	3.4	-0.011	0.22	-0.148
June 105	3.36	42	3.4	-0.025	0.23	0.130	6.28	-58	3.4	-0.008	0.23	-0.213
June 110	1.85	28	2.9	-0.020	0.19	0.086	9.68*	-72	2.9	-0.002	0.19	-0.274

*The options in this table are assumed to be European, so some values may be less than intrinsic value.

It may seem that if one encounters a market where all options are either underpriced or overpriced, the sensible strategies are either long straddles and strangles or short straddles and strangles. Such strategies will enable a trader to take a position with a positive theoretical edge on both sides of the spread. Straddles and strangles are certainly possible strategies when all options are too cheap or too expensive. But we will see in Chapter 13 that straddles and strangles, while often having a large positive theoretical edge, can also be among the riskiest of all strategies. For this reason, a trader will often want to consider other spreads such as ratio spreads and butterflies, even if such spreads entail buying some overpriced options or selling some underpriced options.

An important assumption in traditional theoretical pricing models is that volatility is constant over the life of an option. The volatility input into the model is assumed to be the one volatility that best describes price fluctuations in the underlying instrument over the life of the option. When all options expire at the same time, it is this one volatility that will, in theory, determine whether a spread is profitable or unprofitable. But a trader may also believe that implied volatility will rise or fall over time.

Because calendar spreads are particularly sensitive to changes in implied volatility, rising or falling implied volatility will often affect the profitability of calendar spreads. Consequently, we can add this corollary to the other spread guidelines:

Long calendar spreads are likely to be profitable when implied volatility is low but is expected to rise; short calendar spreads are likely to be profitable when implied volatility is high but is expected to fall.

These are only general guidelines, and an experienced trader may decide to violate them if he has reason to believe that the implied volatility will not correlate with the volatility of the underlying contract. A long calendar spread might still be desirable in a high-implied-volatility market, but the trader must make a prediction of how implied volatility might change with changes in realized volatility. If the market stagnates, with no movement in the underlying contract, but the trader feels that implied volatility will remain high, a long calendar spread is a sensible strategy. The short-term option will decay, while the long-term option will retain its value. In the same way, a short calendar spread might still be desirable in a low-implied-volatility market if the trader feels that the underlying contract is likely to make a large move with no commensurate increase in implied volatility.

Adjustments

A volatility spread may be delta neutral initially, but the delta of the position will change as market conditions change—as the price of the underlying contract rises or falls, as volatility changes, and as time passes. A spread that is delta neutral today is unlikely to be delta neutral tomorrow. The use of a theoretical pricing model requires a trader to continuously maintain a delta-neutral position throughout the life of the spread. Continuous adjustments are neither

possible nor practical in the real world of trading, so when a trader initiates a spread, he ought to give some thought as to how he will adjust the position. There are essentially four possibilities:

1. *Adjust at regular intervals.* In theory, the adjustment process is assumed to be continuous because volatility is assumed to be a continuous measure of the speed of the market. In practice, however, volatility is measured over regular time intervals, so a reasonable approach is to adjust a position at similar regular intervals. If a trader's volatility estimate is based on daily price changes, the trader might adjust daily. If the estimate is based on weekly price changes, he might adjust weekly. By doing this, the trader is making the best attempt to emulate the assumptions built into the theoretical pricing model.
2. *Adjust when the position becomes a predetermined number of deltas long or short.* Very few traders insist on being delta neutral all the time. Most traders accept that this is not a realistic approach both because a continuous adjustment process is physically impossible and because no one can be certain that all the assumptions and inputs in a theoretical pricing model, from which the delta is calculated, are correct. Even if one could be certain that all delta calculations were accurate, a trader might still be willing to take on some directional risk. But a trader ought to know just how much directional risk he is willing to accept. If he wants to pursue delta-neutral strategies but believes that he can comfortably live with a position that is up to 500 deltas long or short, then he can adjust the position any time his delta position reaches this limit. Unlike the trader who adjusts at regular intervals, a trader who adjusts based on a fixed number of deltas cannot be sure how often he will need to adjust his position. In some cases, he may have to adjust very frequently; in other cases, he may go for long periods of time without adjusting.

The number of deltas, either long or short, that a trader is willing to accept without adjusting depends on many factors—the typical size of the trader's positions, his capitalization, and his trading experience. A new independent trader may find that he is uncomfortable with a position that is only 200 deltas long or short. A large trading firm may consider a position that is several thousand deltas long or short as being approximately delta neutral.

3. *Adjust by feel.* This suggestion is not made facetiously. Some traders have good market feel. They can sense when the market is about to move in one direction or another. If a trader has this ability, there is no reason why he shouldn't make use of it. Suppose that the underlying market is at 50.00 and a trader is delta neutral with a gamma of -200 . If the market falls to 48.00, the trader can estimate that he is approximately 400 deltas long. If 400 deltas is the limit of the risk he is willing to accept, he might decide to adjust at this point. If, however, he is also aware that 48.00 represents strong support for the market,

he might choose not to adjust under the assumption that the market is likely to rebound from the support level. If he is right, he will have avoided an unprofitable adjustment. Of course, if he is wrong and the market continues downward through the support level, he will regret not having adjusted. But if the trader is right more often than not, there is no reason why he shouldn't take advantage of this skill.

4. *Don't adjust at all.* This is really an extension of the second possibility, adjusting by the number of deltas. A trader who does not adjust at all is willing to accept a directional risk equal to the maximum number of deltas that the position can take on. If the trader sells five straddles, the position can take on a maximum delta of ± 500 . The appeal of this approach is that it eliminates all subsequent transaction costs. But, if the position takes on a large delta, the directional considerations may become more important than the volatility considerations. If the position was initiated because of an opinion about volatility, does it make sense for a trader to subsequently change to an opinion about direction? Usually not. If the trader does not want to adjust the position but he also does not want directional considerations to dominate, the only choice left is to close out the position. If the trader decides not to adjust, when he initiates the position, he must decide under what conditions he will be willing to hold the position and under what conditions he will close the position.

Submitting a Spread Order

We noted in Chapter 10 that a spread order can often be executed all at one time and at one single price. This is particularly common in option markets, where spreads are quoted with a single bid price and a single offer price regardless of the complexity of the spread. Suppose that a trader is interested in buying a straddle and receives a quote from a market maker of 6.25/6.75. If the trader wants to sell the straddle, he will have to do so at a price of 6.25 (the bid price); if he wants to buy the straddle, he will have to pay 6.75 (the ask price). If the trader decides that he is willing to pay 6.75, neither he nor the market maker really cares whether the trader pays 3.75 for the call and 3.00 for the put or 2.00 for the call and 4.75 for the put or some other combination of call and put prices. The only consideration is that the prices of the call and put taken together add up to 6.75.

A market maker will always endeavor to give one bid price and one ask price for an entire spread. If the spread is a common type, such as a straddle, strangle, butterfly, or calendar spread, a bid and ask can usually be given very quickly. But market makers are only human. If a spread is very complex, involving several different options in unusual ratios, it may take a market maker several minutes to calculate the value of the spread. Regardless of the complexity of a spread, however, the market maker will make an effort to give his best two-sided (bid and ask) market.

Spread orders are common in almost all option markets, whether electronic or open outcry. Depending on the trading platform, an electronic exchange will usually allow traders to submit bids or offers for the most common types of spreads—simple call or put spreads, straddles, strangles, and calendar spreads. More complex spreads—butterflies, Christmas trees, and spreads with unusual ratios—must either be executed piecemeal or submitted to a broker for execution on an open-outcry exchange where an exact description of the spread can be communicated directly to one or more market makers.

Option spread orders may often be submitted with specific instructions as to how the spread is to be executed. Most commonly, a spread will be submitted as either a market order (an order to be filled at the current market price) or a limit order (an order to be filled only at a specified price). But the spread may also be submitted as a *contingency order* with special execution instructions. The following contingency orders, all of which are defined in Appendix A, are often used in option markets:

- All or none
- Fill or kill
- Immediate or cancel
- Market if touched
- Market on close
- Not held
- One cancels the other
- Stop limit order
- Stop loss order

A broker executing a spread order is responsible for adhering to any special instructions that accompany the order. Unless a trader is fully knowledgeable about market conditions or has a great deal of confidence in the broker who will be executing the order, it may be wise to submit specific instructions with the order as to how it is to be executed. Additionally, when one considers all the information that must be communicated with a spread order (i.e., the quantity, the expiration months, the exercise prices, the type of option, and whether the order is a buy or sell), it is easy to see how incorrect information might inadvertently be transmitted with the order. For this reason, it is also wise to double-check all orders before submitting them for execution. Option trading can be difficult enough without the additional problems of miscommunication.

Figure 11-32

Stock price = 100 Time to April expiration = 2 months Volatility = 20% Interest rate = 6.00% Dividend = 0							
Calls				Puts			
Exercise Price	Theoretical Value	Price (Implied Volatility = 17%)	Delta	Theoretical Value	Price (Implied Volatility = 17%)	Delta	
April 90	11.17	11.03	93	.27	0.13	-7	
April 95	6.98	6.64	79	1.04	0.70	-21	
April 100	3.76	3.28	56	2.77	2.29	-44	
April 105	1.71	1.27	33	5.67	5.23	-67	
April 110	.65	.38	16	9.56*	9.29	-84	
Stock price = 100 Time to June expiration = 4 months Volatility = 20% Interest rate = 6.00% Dividend = 0							
Calls				Puts			
Exercise Price	Theoretical Value	Price (Implied Volatility = 17%)	Delta	Theoretical Value	Price (Implied Volatility = 17%)	Delta	
June 90	12.55	12.22	87	0.76	0.44	-13	
June 95	8.71	8.17	75	1.83	1.29	-25	
June 100	5.62	4.95	59	3.64	2.97	-41	
June 105	3.36	2.68	42	6.28	5.60	-58	
June 110	1.85	1.30	28	9.68	9.12	-72	

Figure 11-33

Stock price = 100 Time to April expiration = 2 months Volatility = 20% Interest rate = 6.00% Dividend = 0							
Calls				Puts			
Exercise Price	Theoretical Value	Price (Implied Volatility = 23%)	Delta	Theoretical Value	Price (Implied Volatility = 23%)	Delta	
April 90	11.17	11.36	93	.27	0.47	-7	
April 95	6.98	7.35	79	1.04	1.41	-21	
April 100	3.76	4.24	56	2.77	3.25	-44	
April 105	1.71	2.16	33	5.67	6.12	-67	
April 110	.65	0.97	16	9.56	9.87	-84	
Stock price = 100 Time to June expiration = 4 months Volatility = 20% Interest rate = 6.00% Dividend = 0							
Calls				Puts			
Exercise Price	Theoretical Value	Price (Implied Volatility = 23%)	Delta	Theoretical Value	Price (Implied Volatility = 23%)	Delta	
June 90	12.55	12.94	87	.76	1.15	-13	
June 95	8.71	9.27	75	1.83	2.39	-25	
June 100	5.62	6.29	59	3.64	4.31	-41	
June 105	3.36	4.04	42	6.28	6.96	-58	
June 110	1.85	2.45	28	9.68	10.27	-72	

Long Straddle: Buy calls and puts with the same expiration date and exercise price.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
+10 April 100 calls	10 x -3.76	+10 x 56	+10 x 4.8	+10 x -.035	+10 x .16	+10 x .088
+10 April 100 puts	10 x -2.77	+10 x -44	+10 x 4.8	+10 x -.019	+10 x .16	+10 x -.077
	-65.30	+120	+96.0	-.540	+3.20	+1.10
+10 June 95 calls	10 x -8.71	+10 x 75	+10 x 2.8	+10 x -.026	+10 x .18	+10 x .221
+30 June 95 puts	30 x -1.83	+30 x -25	+30 x 2.8	+30 x -.011	+30 x .18	+30 x -.089
	-142.00	0	+112.0	-.590	+7.20	-.460

(continued)

Figure 11-33 (continued)

Short Straddle: Sell calls and puts with the same expiration date and exercise price.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
-20 April 105 calls	20 x +1.71	-20 x 33	-20 x 4.4	-20 x -.030	-20 x .15	-20 x .052
-10 April 105 puts	10 x +5.67	-10 x -67	-10 x 4.4	-10 x -.013	-10 x .15	-10 x -.121
	+90.90	+10	-132.0	+730	-4.50	-.170
-10 June 100 calls	10 x -5.62	-10 x 59	-10 x 3.4	-10 x -.027	-10 x .22	-10 x .178
-10 June 100 puts	10 x -3.64	-10 x -41	-10 x 3.4	-10 x -.011	-10 x .22	10 x -.148
	+92.60	-180	-68.0	+380	-4.40	-.300
Long Strangle: Buy calls and puts with the same expiration date but different exercise prices.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
+10 April 95 puts	10 x -0.65	+10 x -21	+10 x 3.6	+10 x -0.016	+10 x 0.12	+10 x -0.037
+10 April 110 calls	10 x -1.04	+10 x 16	+10 x 3.0	+10 x -0.019	+10 x 0.10	+10 x 0.025
	-16.90	-50	+66.0	-350	+2.20	-0.120
+20 June 90 puts	20 x -0.76	+20 x -13	+20 x 1.8	+20 x -0.008	+20 x 0.12	+20 x -0.045
+10 June 110 calls	10 x -1.85	+10 x 28	+10 x 2.9	+10 x -0.020	+10 x 0.19	+10 x 0.086
	-33.70	-20	+65.0	-0.360	+4.30	-0.040
Short Strangle: Sell calls and puts with the same expiration date but different exercise prices.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
-30 April 100 puts	30 x +2.77	-30 x -44	-30 x 4.8	-30 x -0.019	-30 x 0.16	-30 x -0.077
-40 April 105 calls	40 x +1.71	-40 x 33	-40 x 4.4	-40 x -0.030	-40 x 0.15	-40 x 0.052
	+151.50	0	-320.0	+1.770	-10.80	+230
-10 June 100 calls	10 x +5.62	-10 x 59	-10 x 3.4	-10 x -0.027	-10 x 0.22	-10 x 0.178
-10 June 105 puts	10 x +6.28	-10 x -58	-10 x 3.4	-10 x -0.008	-10 x 0.23	-10 x -0.213
	+119.00	-10	-68.0	+0.350	-4.50	+0.350

Long Butterfly: Buy one option at a lower exercise price and one option at a higher exercise price, and sell two options at an intermediate exercise price, where all options have the same expiration date and are the same type (either all calls or all puts); there must be an equal amount between exercise prices.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
+10 April 95 calls	10 x -6.98	+10 x 79	+10 x 3.6	+10 x -0.031	+10 x 0.12	+10 x 0.119
-20 April 100 calls	20 x +3.76	-20 x 56	-20 x 4.8	-20 x -0.035	-20 x 0.16	-20 x 0.088
+10 April 105 calls	10 x -1.71	+10 x 33	+10 x 4.4	+10 x -0.030	+10 x 0.15	+10 x 0.052
	-11.70	0	-16.0	+0.090	-0.50	-0.050
+10 June 90 puts	10 x -0.76	+10 x -13	+10 x 1.8	+10 x -0.008	+10 x 0.12	+10 x -0.045
-20 June 95 puts	20 x +1.83	-20 x -25	-20 x 2.8	-20 x -0.011	-20 x 0.18	-20 x -0.089
+10 June 100 puts	10 x -3.64	+10 x -41	+10 x 3.4	+10 x -0.011	+10 x 0.22	+10 x -0.148
	-7.40	-40	-4.0	+0.030	-0.20	-0.150
Short Butterfly: Sell one option at a lower exercise price and one option at a higher exercise price, and buy two options at an intermediate exercise price, where all options have the same expiration date and are the same type (either all calls or all puts); there must be an equal amount between exercise prices.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
-10 April 100 puts	10 x +2.77	-10 x -44	-10 x 4.8	-10 x -0.019	-10 x 0.16	-10 x -0.077
+20 April 105 puts	20 x -5.67	+20 x -67	+20 x 4.4	+20 x -0.013	+20 x 0.15	+20 x -0.121
-10 April 110 puts	10 x +9.56	-10 x -84	-10 x 3.0	-10 x -0.001	-10 x 0.10	-10 x -0.156
	+9.90	-60	+10.0	-0.060	+0.40	-0.090
-10 June 90 calls	10 x +12.55	-10 x 87	-10 x 1.8	-10 x -0.022	-10 x 0.12	-10 x 0.249
+20 June 95 calls	20 x +8.71	+20 x 75	+20 x 2.8	+20 x -0.026	+20 x 0.18	+20 x 0.221
-10 June 100 calls	10 x -5.62	-10 x 59	-10 x 3.4	-10 x -0.027	-10 x 0.22	-10 x 0.178
	+7.50	+40	+4.0	-0.030	+0.20	+0.150

(continued)

Figure 11-33 (continued)

Long Condor: Buy two options at two outside exercise prices and sell two options at two inside exercise prices, where all options have the same expiration date and are the same type (either all calls or all puts); there must be an equal amount between the two higher and two lower exercise prices.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
+10 April 90 calls	10 x -11.17	+10 x 93	+10 x 1.7	+10 x -0.023	+10 x 0.06	+10 x 0.136
-10 April 95 calls	10 x +6.98	-10 x 79	-10 x 3.6	-10 x -0.031	-10 x 0.16	-10 x 0.119
-10 April 105 calls	10 x +1.71	-10 x 33	-10 x 4.4	-10 x -0.030	-10 x 0.15	-10 x 0.052
+10 April 110 calls	<u>10 x -0.65</u> -31.30	<u>+10 x 16</u> -30	<u>+10 x 3.0</u> -33.0	<u>+10 x -0.019</u> +0.190	<u>+10 x 0.10</u> -1.10	<u>+10 x 0.025</u> -0.100
+10 June 95 puts	10 x -1.83	+10 x -25	+10 x 2.8	+10 x -0.011	+10 x 0.18	+10 x -0.089
-10 June 100 puts	10 x +3.64	-10 x -41	-10 x 3.4	-10 x -0.011	-10 x 0.22	-10 x -0.148
-10 June 105 puts	10 x +6.28	-10 x -58	-10 x 3.4	-10 x -0.008	-10 x 0.23	-10 x -0.213
+10 June 110 puts	<u>10 x -9.68</u> -15.90	<u>+10 x -72</u> +20	<u>+10 x 2.9</u> -11.0	<u>+10 x -0.002</u> +0.060	<u>+10 x 0.19</u> -0.80	<u>+10 x -0.274</u> -0.020
Short Condor: Sell two options at two outside exercise prices and buy two options at two inside exercise prices, where all options have the same expiration date and are the same type (either all calls or all puts); there must be an equal amount between the two higher and two lower exercise prices.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
-10 April 90 puts	10 x +2.7	-10 x -7	-10 x 1.7	-10 x -0.008	-10 x 0.06	-10 x -0.013
+10 April 95 puts	10 x -1.04	+10 x -21	+10 x 3.6	+10 x -0.016	+10 x 0.12	+10 x -0.037
+10 April 100 puts	10 x -2.77	+10 x -44	+10 x 4.8	+10 x -0.019	+10 x 0.16	+10 x -0.077
-10 April 105 puts	<u>10 x +5.66</u> +21.30	<u>-10 x -67</u> +90	<u>-10 x 4.4</u> +23.0	<u>-10 x -0.013</u> -0.140	<u>-10 x 0.15</u> +0.70	<u>-10 x -0.121</u> +0.200
+10 June 90 calls	10 x -1.83	+10 x 87	+10 x 1.8	+10 x -0.008	+10 x 0.12	+10 x 0.249
-10 June 95 calls	10 x +3.64	-10 x 75	-10 x 2.8	-10 x -0.011	-10 x 0.18	-10 x 0.221
-10 June 105 calls	10 x +6.28	-10 x 42	-10 x 3.4	-10 x -0.008	-10 x 0.23	-10 x 0.130
+10 June 110 calls	<u>10 x -9.68</u> +23.30	<u>+10 x 28</u> +20	<u>+10 x 2.9</u> +15.0	<u>+10 x -0.002</u> -0.090	<u>+10 x 0.19</u> +1.00	<u>+10 x 0.086</u> +0.160
Call Ratio Spread (long more than short): Buy more calls at a higher exercise price and sell fewer calls at a lower exercise price where all options have the same expiration date.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
+20 April 110 calls	20 x -0.65	+20 x 16	+20 x 3.0	+20 x -0.019	+20 x 0.10	+20 x 0.025
-10 April 105 calls	<u>10 x +1.71</u> +4.10	<u>-10 x 33</u> -10	<u>-10 x 4.4</u> +16.0	<u>-10 x -0.030</u> -0.080	<u>-10 x 0.15</u> +0.50	<u>-10 x 0.052</u> -0.020
+30 June 110 calls	30 x -1.85	+30 x 28	+30 x 2.9	+30 x -0.020	+30 x 0.19	+30 x 0.086
-10 June 90 calls	<u>10 x +12.55</u> +70.00	<u>-10 x 87</u> -30	<u>-10 x 1.8</u> +69.0	<u>-10 x -0.022</u> -0.380	<u>-10 x 0.12</u> +4.50	<u>-10 x 0.249</u> +0.090
Call Ratio Spread (short more than long): Sell more calls at a higher exercise price and buy fewer calls at a lower exercise price where all options have the same expiration date.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
+20 April 95 calls	20 x -6.98	+20 x 79	+20 x 3.6	+20 x -0.031	+20 x 0.12	+20 x 0.119
-30 April 100 calls	<u>30 x +3.76</u> -26.80	<u>-30 x 56</u> -100	<u>-30 x 4.8</u> -72.0	<u>-30 x -0.035</u> +0.430	<u>-30 x 0.16</u> -2.40	<u>-30 x 0.088</u> -0.260
+10 June 100 calls	10 x -5.62	+10 x 59	+10 x 3.4	+10 x -0.027	+10 x 0.22	+10 x 0.178
-20 June 110 calls	<u>20 x -1.85</u> -19.20	<u>-20 x 28</u> +30	<u>-20 x 2.9</u> -24.0	<u>-20 x -0.020</u> +0.130	<u>-20 x 0.19</u> -1.60	<u>-20 x 0.086</u> +0.060

(continued)

Figure 11-33 (continued)

Put Ratio Spread (long more than short): Buy more puts at a lower exercise price and sell fewer puts at a higher exercise price where all options have the same expiration date.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
+40 April 95 puts	40 x -1.04	+40 x -21	+40 x 3.6	+40 x -0.016	+40 x 0.12	+40 x -0.037
-10 April 110 puts	<u>10 x +9.56</u>	<u>-10 x -84</u>	<u>-10 x 3.0</u>	<u>-10 x -0.001</u>	<u>-10 x 0.10</u>	<u>-10 x -0.156</u>
	+54.00	0	+114.0	-0.630	+3.80	+0.080
+50 June 95 puts	50 x -1.83	+50 x -25	+50 x 2.8	+50 x -0.011	+50 x 0.18	+50 x -0.089
-20 June 105 puts	<u>20 x +6.28</u>	<u>-20 x -58</u>	<u>-20 x 3.4</u>	<u>-20 x -0.008</u>	<u>-20 x 0.23</u>	<u>-20 x -0.213</u>
	+34.10	-90	+72.0	-0.390	+4.40	-0.190
Put Ratio Spread (short more than long): Sell more puts at a lower exercise price and buy fewer puts at a higher exercise price where all options have the same expiration date.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
+10 April 105 puts	10 x -5.67	+10 x -67	+10 x 4.4	+10 x -0.013	+10 x 0.15	+10 x -0.121
-30 April 95 puts	<u>30 x +1.04</u>	<u>-30 x -21</u>	<u>-30 x 3.6</u>	<u>-30 x -0.016</u>	<u>-30 x 0.12</u>	<u>-30 x -0.037</u>
	-25.50	-40	-64.0	+0.350	-2.10	-0.100
+30 June 105 puts	30 x -6.28	+30 x -58	+30 x 3.4	+30 x -0.008	+30 x 0.23	+30 x -0.213
-40 June 100 puts	<u>40 x +3.24</u>	<u>-40 x -41</u>	<u>-40 x 3.4</u>	<u>-40 x -0.011</u>	<u>-40 x 0.22</u>	<u>-40 x -0.148</u>
	-42.80	-100	-34.0	+0.020	-1.90	-0.470
Long Call Christmas Tree: Buy a call at a lower exercise price and sell one call each at two higher exercise prices, where all options have the same expiration date.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
+10 April 100 calls	10 x -3.76	+10 x 56	+10 x 4.8	+10 x -0.035	+10 x 0.16	+10 x 0.088
-10 April 105 calls	10 x +1.71	-10 x 33	-10 x 4.4	-10 x -0.030	-10 x 0.15	-10 x 0.052
-10 April 110 calls	<u>10 x +0.65</u>	<u>-10 x 16</u>	<u>-10 x 3.0</u>	<u>-10 x -0.019</u>	<u>-10 x 0.10</u>	<u>-10 x 0.025</u>
	-14.00	+70	-26.0	+0.140	-0.90	+0.110
+10 June 90 calls	10 x -12.55	+10 x 87	+10 x 1.8	+10 x -0.022	+10 x 0.12	+10 x 0.249
-10 June 100 calls	10 x +5.62	-10 x 59	-10 x 3.4	-10 x -0.027	-10 x 0.22	-10 x 0.178
-10 June 110 calls	<u>10 x +1.85</u>	<u>-10 x 28</u>	<u>-10 x 2.9</u>	<u>-10 x -0.020</u>	<u>-10 x 0.19</u>	<u>-10 x 0.086</u>
	-50.80	0	-45.0	+0.250	-2.90	-0.150
Short Call Christmas Tree: Sell a call at a lower exercise price and buy one call each at two higher exercise prices, where all options have the same expiration date.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
-10 April 90 calls	10 x +11.17	-10 x 93	-10 x 1.7	-10 x -0.023	-10 x 0.06	-10 x 0.136
+10 April 100 calls	10 x -3.76	+10 x 56	+10 x 4.8	+10 x -0.035	+10 x 0.16	+10 x 0.088
+10 April 105 calls	<u>10 x -1.71</u>	<u>+10 x 33</u>	<u>+10 x 4.4</u>	<u>+10 x -0.030</u>	<u>+10 x 0.15</u>	<u>+10 x 0.052</u>
	+57.00	-40	+75.0	-0.420	+2.50	+0.040
-10 June 95 calls	10 x +8.71	-10 x 75	-10 x 2.8	-10 x -0.026	-10 x 0.18	-10 x 0.221
+10 June 105 calls	10 x -3.36	+10 x 42	+10 x 3.4	+10 x -0.025	+10 x 0.23	+10 x 0.130
+10 June 110 calls	<u>10 x +1.85</u>	<u>+10 x 28</u>	<u>+10 x 2.9</u>	<u>+10 x -0.020</u>	<u>+10 x 0.19</u>	<u>+10 x 0.086</u>
	+35.00	-50	+35.0	-0.190	+2.40	-0.050

(continued)

Figure 11-33 (continued)

Long Put Christmas Tree: Sell one put each at two lower exercise prices and buy a put at higher exercise price, where all options have the same expiration date.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
-10 April 95 puts	10 x +1.04	-10 x -21	-10 x 3.6	-10 x -0.016	-10 x 0.12	-10 x -0.037
-10 April 100 puts	10 x +2.77	-10 x -44	-10 x 3.8	-10 x -0.019	-10 x 0.16	-10 x -0.077
+10 April 105 puts	<u>10 x -5.67</u> -18.60	<u>+10 x -67</u> -20	<u>+10 x 4.4</u> -30.0	<u>+10 x -0.013</u> +0.220	<u>+10 x 0.15</u> -1.30	<u>+10 x -0.121</u> -0.070
-10 June 90 puts	10 x +.76	-10 x -13	-10 x 1.8	-10 x -0.008	-10 x 0.12	-10 x -0.045
-10 June 105 puts	10 x +6.28	-10 x -58	-10 x 3.4	-10 x -0.008	-10 x 0.23	-10 x -0.213
+10 June 110 puts	<u>10 x -9.68</u> -26.40	<u>+10 x -72</u> -10	<u>+10 x 2.9</u> -23.0	<u>+10 x -0.002</u> +0.140	<u>+10 x 0.19</u> -1.60	<u>+10 x -0.274</u> -0.160
Short Put Christmas Tree: buy one put each at two lower exercise prices and sell a put at a higher exercise price, where all options have the same expiration date.						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
+10 April 95 puts	10 x -1.04	+10 x -21	+10 x 3.6	+10 x -0.016	+10 x 0.12	+10 x -0.037
+10 April 105 puts	10 x -5.67	+10 x -67	+10 x 4.4	+10 x -0.013	+10 x 0.15	+10 x -0.121
-10 April 110 puts	<u>10 x +9.56</u> +28.50	<u>-10 x -84</u> -40	<u>-10 x 3.0</u> +50.0	<u>-10 x -0.001</u> -0.280	<u>-10 x 0.10</u> +1.70	<u>-10 x -0.156</u> -0.020
+10 June 90 puts	10 x -.76	+10 x -13	+10 x 1.8	+10 x -0.008	+10 x 0.12	+10 x -0.045
+10 June 95 puts	10 x -1.83	+10 x -25	+10 x 2.8	+10 x -0.011	+10 x 0.18	+10 x -0.089
-10 June 100 puts	<u>10 x +3.64</u> +10.50	<u>-10 x -41</u> +30	<u>-10 x 3.4</u> +12.0	<u>-10 x -0.011</u> -0.080	<u>-10 x 0.22</u> +0.80	<u>-10 x -0.148</u> +0.140
Long Calendar Spread: Buy a long-term option and sell a short-term option where both options have the same exercise price and are the same type (either both calls or both puts).						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
+10 June 100 calls	10 x -5.62	+10 x 59	+10 x 3.4	+10 x -0.027	+10 x 0.22	+10 x 0.178
-10 April 100 calls	<u>10 x +3.76</u> -18.60	<u>-10 x 56</u> +30	<u>-10 x 4.8</u> -14.0	<u>-10 x -0.035</u> +0.080	<u>-10 x 0.16</u> +0.60	<u>-10 x 0.088</u> +0.900
+10 June 95 puts	10 x -1.83	+10 x -25	+10 x 2.8	+10 x -0.011	+10 x 0.18	+10 x -0.089
-10 April 95 puts	<u>10 x +1.04</u> -7.90	<u>-10 x -21</u> -40	<u>-10 x 3.6</u> -8.0	<u>-10 x -0.016</u> +0.050	<u>-10 x 0.12</u> +0.60	<u>-10 x -0.037</u> -0.520
Short Calendar Spread: Buy a short-term option and sell a long-term option where both options have the same exercise price and are the same type (either both calls or both puts).						
	Theoretical Value (Cash Flow)	Total Delta	Total Gamma	Total Theta	Total Vega	Total Rho
+10 April 105 calls	10 x -1.71	+10 x 33	+10 x 4.4	+10 x -0.030	+10 x 0.15	+10 x 0.052
-10 June 105 calls	<u>10 x +3.36</u> +16.50	<u>-10 x 42</u> -90	<u>-10 x 3.4</u> +10.0	<u>-10 x -0.025</u> -0.050	<u>-10 x 0.23</u> -0.80	<u>-10 x 0.130</u> -0.780
+10 April 100 puts	10 x -2.77	+10 x -44	+10 x 4.8	+10 x -0.019	+10 x 0.16	+10 x -0.077
-10 June 100 puts	<u>10 x -3.64</u> +8.70	<u>-10 x -41</u> -30	<u>-10 x 3.4</u> +14.0	<u>-10 x -0.011</u> -0.080	<u>-10 x 0.22</u> -0.60	<u>-10 x -0.148</u> +0.710