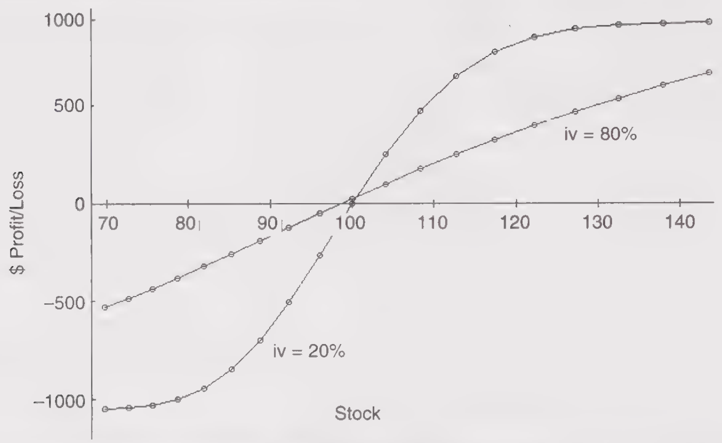
FIGURE 37-4.
Bull spread profit picture in 30 days.



As a corollary, note that if implied volatility *shrinks* while the stock rises, the profit outlook will improve. Graphically, using Figure 37-4, if one's profit picture moves from the 80% curve to the 20% curve on the right-hand side of the chart, that is a positive development. Of course, if the stock drops and the implied volatility drops too, then one's losses would be worse—witness the left-hand side of the graph in Figure 37-4.

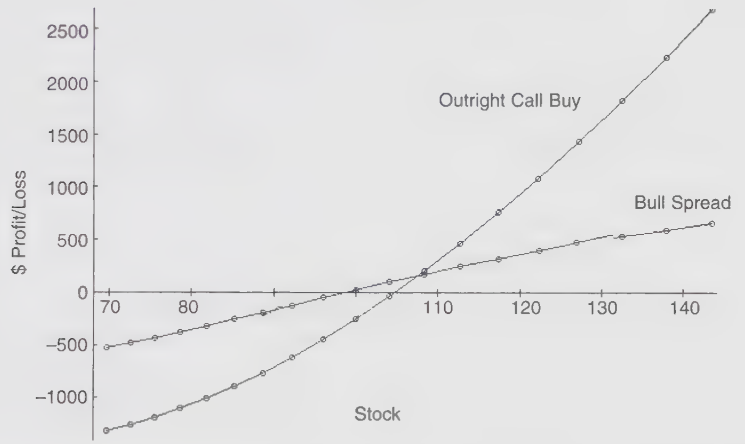
A graph could be drawn that would incorporate other implied volatilities, but that would be overkill. The profit graphs of the other spreads from Tables 37-6 or 37-7 would lie between the two curves shown in Figure 37-4.

If this discussion had looked at bull spreads as *put credit* spreads instead of call debit spreads, perhaps these conclusions would not have seemed so unusual. Experienced option traders already understand much of what has been shown here, but less experienced traders may find this information to be different from what they expected.

Some general facts can be drawn about the bull spread strategy. Perhaps the most important one is that, if used on a volatile stock, you won't get much expansion in the spread even if the stock makes a nice move upward in your favor. In fact, for high implied volatility situations, the bull spread won't expand out to its maximum price until expiration draws nigh. That can be frustrating and disappointing.

Often, the bull spread is established because the option trader feels the options are "too expensive" and thus the spread strategy is a way to cut down on the total debit invested. However, the ultimate penalty paid is great. Consider the fact that, if the stock

FIGURE 37-5.
Call buy versus bull spread in 30 days; IV = 80%.



rose from 100 to 130 in 30 days, *any* reasonable four-month call purchase (i.e., with a strike initially near the current stock price) would make a nice profit, while the bull spread barely ekes out a 5-point gain. To wit, the graph in Figure 37-5 compares the purchase of the at-the-money call with a striking price of 100 and the 90–110 call bull spread, both having implied volatility of 80%. Quite clearly, the call purchase dominates to a great extent on an upward move. Of course, the call purchase does worse on the downside, but since these are bullish strategies, one would have to assume that the trader had a positive outlook for the stock when the position was established. Hence, what happens on the downside is not primary in his thinking.

The bull spread and the call purchase have opposite position vegas, too. That is, a rise in implied volatility will help the call purchase but will harm the bull spread (and vice versa). *Thus, the call purchase and the bull spread are not very similar positions at all.*

If one wants to use the bull spread to effectively reduce the cost of buying an expensive at-the-money option, then at least make sure the striking prices are quite wide apart. That will allow for a reasonable amount of price appreciation in the bull spread if the underlying rises in price. Also, one might want to consider establishing the bull spread with striking prices that are *both* out-of-the-money. Then, if the stock rallies strongly, a greater percentage gain can be had by the spreader. Still, though, the facts described above cannot be overcome; they can only possibly be mitigated by such actions.

A FAMILIAR SCENARIO?

Often, one may be deluded into thinking that the two positions are more similar than they are. For example, one does some sort of analysis—it does not matter if it's fundamental or technical—and comes to a conclusion that the stock (or futures contract or index) is ready for a bullish move. Furthermore, he wants to use options to implement his strategy. But, upon inspecting the actual market prices, he finds that the options seem rather expensive. So, he thinks, "Why not use a bull spread instead? It costs less and it's bullish, too."

Fairly quickly, the underlying moves higher—a good prediction by the trader, and a timely one as well. If the move is a violent one, especially in the futures market, implied volatility might increase as well. If you had bought calls, you'd be a happy camper. But if you bought the bull spread, you are not only highly disappointed, but you are now facing the prospect of having to hold the spread for several more weeks (perhaps months) before your spread widens out to anything even approaching the maximum profit potential.

Sound familiar? Every option trader has probably done himself in with this line of thinking at one time or another. At least, now you know the reason why: High or increasing implied volatility is not a friend of the bull spread, while it is a friendly ally of the outright call purchase. Somewhat surprisingly, many option traders don't realize the difference between these two strategies, which they probably consider to be somewhat similar in nature.

So, be careful when using bull spreads. If you really think a call option is too expensive and want to reduce its cost, try this strategy: Buy the call and simultaneously sell a credit put spread (bull spread) using slightly out-of-the-money puts. This strategy reduces the call's net cost and maintains upside potential (although it increases downside risk, but at least it is still a fixed risk).

Example: With XYZ at 100, a trader is bullish and wants to buy the July 100 calls, which expire in two months. However, upon inspection, he finds that they are trading at 10—an implied volatility of 59%. He knows that, historically, the implied volatility of this stock's options range from approximately 40% to 60%, so these are very expensive options. If he buys them now and implied volatility returns to its median range near 50%, he will suffer from the decrease in implied volatility.

As a possible remedy, he considers selling an out-of-the-money put credit spread at the same time that he buys the calls. The credit from this spread will act as a means of reducing the net cost of the calls. If he's right and the stock goes up, all will be well. However, the introduction of the put spread into the mix has introduced some additional downside risk.

Suppose the following prices exist:

XYZ: 100
July 100 call: 10 (as stated above)
July 90 put: 5
July 80 put: 2

The entire bullish position would now consist of the following:

Buy 1 July 100 call at 10
Buy 1 July 80 put at 2
Sell 1 July 90 put at 5
Net expenditure: 7 point debit (plus commission)

Figure 37-6 shows the profitability, at expiration, of both the outright call purchase and the bullish position constructed above.

First, one can see that the bullish spread position has a total risk of 17 points, if XYZ is below 80 (the lower striking price of the put spread) at expiration. That, of course, is more than the 10-point cost of the July 100 call by itself, but if one is using a trading stop of any sort, he probably would not be at risk for the entire 17 points, since he wouldn't

FIGURE 37-6.
Profitability at expiration.

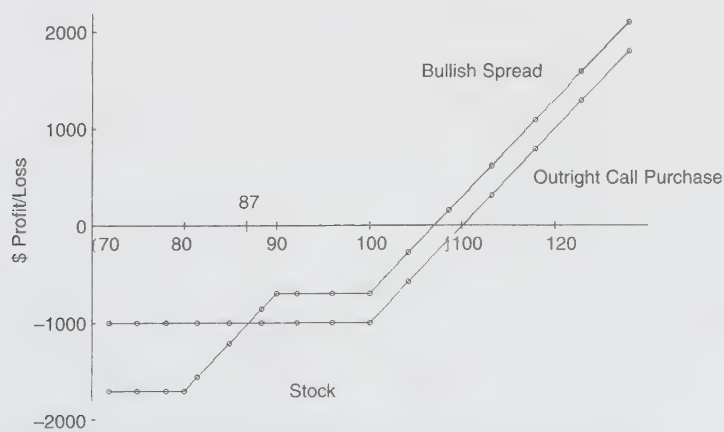
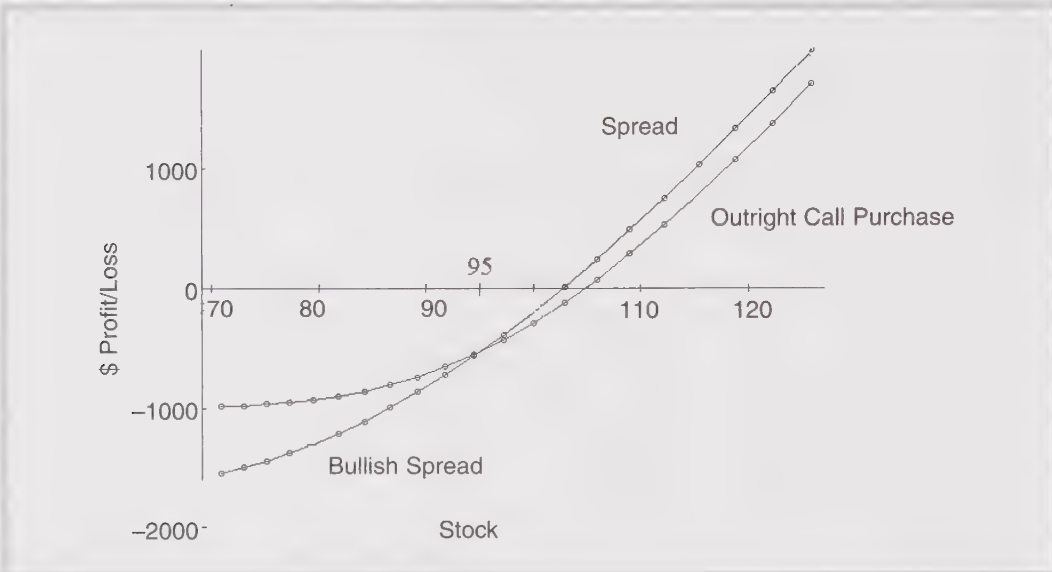


FIGURE 37-7.
Results of the two positions in 30 days.



hold on while the stock fell all the way to 80 and below. Note also that the bullish spread position would have a loss of 10 points (the same as the call) at a price of 87 for the common at expiration. Hence, the combined position actually has *less* risk than the outright call purchase as long as XYZ is 87 or higher at expiration. Since one is supposedly bullish initially when establishing this strategy, it seems likely that he would figure the stock would be 87 or higher at expiration.

Figure 37-7 offers another comparison, that of the two positions after 30 days have passed. Note that the spread position once again does better on the upside and worse on the downside. The crossover point between the two curves is at about a price of 95. That is, if XYZ is above 95 in 30 days, the bullish spread position will outperform the call buy.

One final point should be made regarding the investment required. The outright call purchase requires an investment of $1,000—the cost of the long call. The bullish spread position requires that $1,000, plus $700 for the spread (10-point difference in the strikes, less the 3-point credit received for selling the spread). That's a total of $1,700, the risk of the bullish spread position. Hence, the *rate of return* might favor the outright call purchase, depending on how far the stock rallies.

Overall, the bullish spread position is an attractive alternative to an outright call purchase, especially when the call is overpriced. The spread does risk a greater amount of money if the underlying stock should collapse heavily. Still, if one is truly bullish, and if one employs a reasonably tight downside stop on his entire position, this spread can perform better than the outright purchase of an overpriced call.

VERTICAL PUT SPREADS

Also of interest is the effect that implied volatility has on put spreads. One of the more popular strategies involving puts is the sale of a credit spread—a bull spread with puts. Assume that a stock is selling at 100, and one is going to *sell a put with a 110 strike and buy a put with a 90 strike.* That is a put credit (bull) spread. Also assume that the options have four months of life remaining. (See Table 37-8.)

One would not rationally sell this credit spread if implied volatility were as low as 20%, because at that low level of volatility, the in-the-money December 110 put is trading for 10 dollars—parity—and thus would immediately be at risk of early assignment. But one can see that an increase in implied volatility increases the value of the spread. Now, if one had sold this spread to begin with, he would thus be *losing* money when implied volatility increased. This was proven with call bull spreads, too: They lose money when implied volatility increases. Conversely, of course, the put credit spread *makes* money when implied volatility decreases.

What happens after thirty days have passed? Figure 37-8 shows just two cases—implied volatility at 30% and implied volatility at 80%. One can surmise that other levels of implied volatility between 30% and 80% would have profit graphs that lie between the two shown in Figure 37-8.

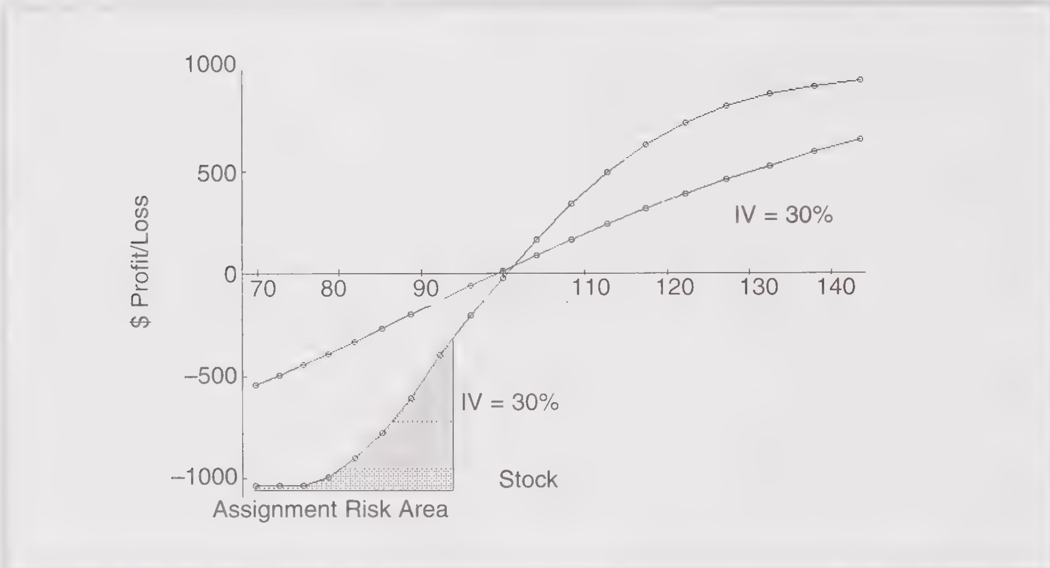
First, one can observe that a bull put spread does not widen out to anywhere near its maximum potential if implied volatility increases. The same thing was seen with the call

TABLE 37-8.

Implied Volatility	90–110 Put Bull Spread (Theoretical Value)
20%	9.15 cr*
30%	9.70 cr
40%	10.12 cr
50%	10.46 cr
60%	10.78 cr
70%	11.05 cr
80%	11.33 cr

*Short option trading at parity

FIGURE 37-8.
Put credit (bull) spread profit in 30 days.



bull spread in the previous section. But a put bull spreader is caught in another trap: If implied volatility falls and the stock falls too, the risk of early assignment materializes quickly. Note the shaded area at the lower left of the graph, extending from a price of about 94 on down. After thirty days (so there would be three months' life remaining at that point in time), if implied volatility is 30%, the 110 put (the short put) would be trading at parity for stock prices of 94 and below. Thus, it would be at risk of early assignment. If implied volatility were even lower, the puts would be at parity for much higher stock prices.

Now, in and of itself, early assignment on an equity or futures put spread is not necessarily a terrible thing. There will be a request for additional margin (because the stock has to be paid for or the futures contract margined), but the risk is still the same in dollar terms. Of course, the request for extra margin could be backbreaking for a stock trader if he can't afford to fully pay for the stock, and the early assignment would probably incur additional commission costs, too. However, with cash-based index options there is a more serious increase in risk after an early assignment, because one is left with only the long side of the spread. If that option happens to have substantial value, then there is considerable risk if the underlying should quickly move higher. In fact, by the time one unwinds the spread, he might actually end up losing more than his original limited risk amount—all due to the early assignment. (This could happen if the underlying first plunges in price, placing both options deeply in-the-money, after which one gets assigned on the short put option, followed by the underlying then dramatically rising in price.)

The lesson to be learned is this: *If one is considering using bull spreads in which at least one of the options is at- or in-the-money, then a call bull spread is a superior choice over a put bull spread*. Early assignment is not really a consideration for most call spreads.

In both cases, however, a more serious problem exists, and that is that the spread does not widen out much even when the stock makes a nice bullish move. Thus, once again it is actually better to buy a call option in most cases than to use the bull spread, because profits are larger and an increase in implied volatility is a favorable thing for an outright call buyer.

Note that these effects are similar, but much less pronounced, for out-of-the-money put credit spreads. Still, it should be noted that an increase in implied volatility will harm an out-of-the-money put credit spread, too. Hence, if the underlying goes into a rapid fall (crash, plunge), then implied volatility usually increases quickly and dramatically. So an out-of-the-money credit spreader is hit with the double whammy of expanding implied volatility and the fact that the underlying is fast approaching the strike price of his options, thereby expanding the price of the spread.

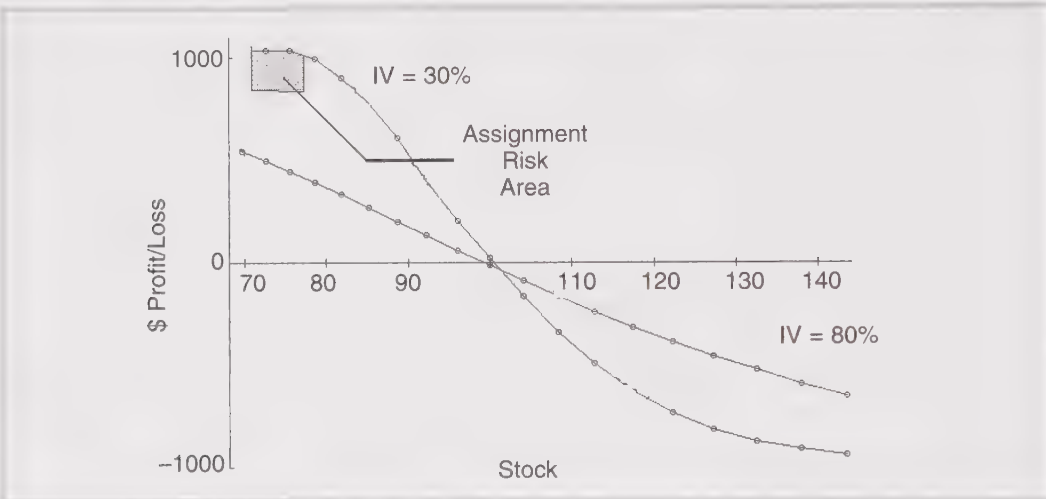
PUT BEAR SPREADS

What about the put spread in a bearish situation? In a vertical put spread one *buys* the put with the higher strike and *sells* the put with the lower strike to construct a simple put bear spread. Actually, a sudden increase in implied volatility is of help to the bear put spread. That is, the spread will widen out slightly. To verify this, look at Table 37-8 again, only now imagine that one is *buying* the spread for a debit. Note that the smallest debit is at the lower implied volatility—9.15 debit with IV at 30%. If implied volatility were to instantaneously jump to 80%, the spread would widen out to 11.33 debit. A very quick profit could be had. So there's a difference right away between a debit call bull spread (which *loses* money when implied volatility suddenly increases) and a debit put bear spread.

Unfortunately, the other major drawback—that the spread doesn't widen out much if the underlying makes a favorable move—is still true. Figure 37-9 shows a bear put spread, 30 days hence, for two different implied volatilities. Once again, the lower-volatility spread widens out more quickly, because both options tend to go to parity in that case. In fact, one can see on the graph that there is early assignment risk in the low-volatility case, below a price of about 77 on the stock. That is not a problem, though, since the spread would have widened to its maximum potential in that case and could just be removed when the risk of early assignment materialized.

When implied volatility remains high, though, the spread doesn't widen out much, even when the stock drops a lot after 30 days. Since it is common for implied volatility to rise (even skyrocket) when the underlying drops quickly, the put bear spread probably

FIGURE 37-9.
Bear put spread profit in 30 days.



won't widen out much. That may not be a psychologically pleasing strategy, because one won't make the level of profits that he had hoped to when the underlying fell quickly.

Once again, it seems that the outright purchase of an option is probably superior to a spread. In these cases, it is true with respect to puts, much as it was with call options. Spreading often unnecessarily complicates a trader's outlook.

CALENDAR SPREADS

In the earlier chapter on calendar spreads, it was mentioned that an increase in implied volatility will cause a calendar spread to widen out. Both options will become more expensive, of course, since the increase in implied volatility affects both of them, but the *absolute* price change will be greatest in the long-term option. Therefore, the calendar spread will widen. This may seem somewhat counterintuitive, especially where highly volatile stocks are concerned, so some examples may prove useful.

Example: Suppose that XYZ is trading at 100, and one is interested in a calendar spread in which an August (5-month) call is bought and a May (2-month) call is sold. For the purpose of this example, it will be assumed that these are both at-the-money options. First, the vegas of the two options will be examined, assuming that implied volatility is 40%:

Stock: 100
Implied Volatility:

40% Option	Theoretical Price	Vega
Sell May 100 call	6.91	0.162
Buy August 100 call	11.22	0.251

In theory, this spread should be worth 4.31—the difference in the theoretical values. Perhaps more important, it has volatility exposure of 0.089—the difference between the vega of the long call and that of the short call. Since vega is positive, this means that an *increase* in implied volatility will be beneficial to the spread. In other words, one can expect the spread to widen if implied volatility rises, and can expect the spread to shrink if implied volatility declines.

The following table can also be constructed, showing the theoretical value of the spread at various levels of implied volatility. This table makes the assumption that very little time has passed (only one week) before the implied volatility changes take place. It also assumes that the stock is still at 100.

Stock Price: 100

One week after the spread has been established:

Implied Volatility	Theoretical Spread Value
20%	2.58
30%	3.52
40%	4.46
50%	5.40
60%	6.33
80%	8.16
100%	12.92

From the above data, it is quite obvious that implied volatility levels have a huge effect on the value of a calendar spread. The actual initial contribution of time decay is rather small in comparison. For example, note that if volatility remains unchanged at 40%, then the spread will have widened only slightly—to 4.46 from 4.31—after the passage of one week's time. That is small in comparison to the changes dictated by volatility expansion or contraction.

A common mistake that calendar spreaders make is to think that such a spread looks overly attractive on a very volatile stock. Consider the same stock as above, still trading at

100, but for some reason implied volatility has skyrocketed to 80% (perhaps a takeover rumor is present).

Stock: 100
Implied Volatility: 80%

Call	Theoretical Value
May 100 call	12.55
June 100 call	16.81

On the surface, this seems like a very attractive spread. There are two months of life remaining in the May options (and three months in the Junes) and the spread is trading at 4.36. However, both options are completely composed of time value premium, and most certainly the June 100 call would be worth far more than 4.36 when the May expires, if the stock is still near 100. The fact that many traders miss when they think of the calendar spread this way is that the June call will only be worth "far more than 4.36" if implied volatility holds up. If implied volatility for this stock is normally something on the order of 40%, say, then it is probably not reasonable to expect that the 80% level will hold up. Just for comparison, note that if the stock is at 100 at May expiration—the maximum profit potential for such a calendar spread—the June 100 call, with implied volatility now at 40%, and with one month of life remaining, would be worth only 4.77. Thus the spread would only have made a profit of a few cents (4.36 to 4.77), and if the underlying stock were farther from the strike price at expiration, there would probably be a loss rather than a profit.

The point to be remembered is that a calendar spread is a "long volatility" play (and a reverse calendar spread is just the opposite). Evaluate the position's risk with an eye to what might happen to implied volatility, and not just to where the stock price might go or how much time decay there might be in the position.

RATIO SPREADS AND BACKSPREADS

The previous descriptions in this chapter describe fairly fully and accurately what the effect of volatility changes are. More complicated strategies are usually nothing more than combinations of the strategies presented earlier, so it is easy to discern the effect that changes in implied volatility would have; just combine the effects on the simpler strategies. For example, a ratio call write is really just the equivalent of a straddle sale—a strategy whose volatility ramifications are fairly simple to understand.

Ratio spreads, on the other hand, might not be as intuitive to interpret, but they are fairly simple nonetheless. A call ratio spread is really just the combination of some call bull spreads and some naked call options. For example, a call ratio spread might consist of buying an XYZ July 100 call and selling two XYZ July 120 calls. If one were to break it down into its components, this spread is really long one XYZ July 100–120 call bull spread, plus an additional naked July 120 call.

We already know that an increase in implied volatility is very detrimental to a naked call option. In addition, it was shown earlier than an increase in implied volatility actually *harms* the value of an at-the-money call bull spread. So, for a ratio call spread, *both* components are harmed by an increase in implied volatility. Conversely, a *decrease* in implied volatility would be beneficial to a ratio spread, but where naked options are concerned, one should be more mindful of his risk than of this reward.

It was also shown previously that a call bull spread does *not* widen out much if the underlying stock makes a quick upward move. The spread won't widen out to its maximum profit potential until expiration draws nigh or the stock is well above the upper strike in the spread. This scenario also does not bode well for the ratio call spread. Suppose that the underlying stock suddenly jumps upward and implied volatility increases at the same time. That combination is seen quite frequently, especially if the stock were previously "dull" or if there is some sort of active corporate (takeover) rumor. The call ratio spread will fare miserably under these conditions, because the increase in stock price certainly harms the naked call position and the bull spread is not widening out much to compensate for it. In addition, the increase in implied volatility is working against both components.

The same sort of thing happens with put ratio spreads. They are really the combination of a put bear spread plus some additional naked put options. If the underlying falls in price, while implied volatility increases—a very common occurrence in all markets—then the put ratio spread will fare poorly. In fact, implied volatility sometimes *explodes* if the underlying falls very rapidly (crashes), so the ratio put spreader should clearly assess his risk in this light.

In summary, a trader utilizing ratio spread strategies should clearly understand and attempt to analyze the risks of an increase in implied volatility. This includes not only assessing the vega risk of the spread, but also using a probability calculator with some inflated volatility estimates to see just what the chances are of the spread getting into real trouble.

BACKSPREADS

A call backspread is merely the opposite of a call ratio spread. Thus, any of the earlier commentary about how an increase in implied volatility is detrimental to a ratio spread can be reversed when discussing the backspread. An increase in implied volatility will be beneficial to a backspread strategy, while a decrease in implied volatility will be slightly harmful to the spread. However, since risk is limited in a backspread, such a decrease in implied volatility would not have catastrophic consequences unless one had overcommitted his funds to one position.

SUMMARY

In general, one can always determine the exposure of his position to volatility by computing the vega of this position. However, it is also useful for a strategist to have some general feeling for how implied volatility will affect his positions and strategies. Thus, this chapter was designed to point out the most common effects that changes in implied volatility will have on the basic types of option strategies. Once one has a feeling for his exposure to volatility, he can then assess whether an adverse volatility movement is likely. For example, if an increase in implied volatility would be harmful, and the strategist sees that current levels of implied volatility are quite low in comparison to historical norms, then perhaps he should remove or adjust the position.

Volatility and the price of the underlying are the two major components affecting profitability for most option positions. Time decay is only most pertinent as expiration approaches. Yet, many traders concentrate greatly on potential price movements of the underlying, often while ignoring what changes in implied volatility could do. That is a mistake, for the most knowledgeable option traders plan for volatility risk at all times. Understanding and handling that risk can have a positive effect on an option trader's profits.

CHAPTER 38

The Distribution of Stock Prices

Much of the work that has been done in statistics and related areas regarding the stock market has made the assumption that stock prices are distributed normally, or more specifically, *lognormally*. In actual practice, this is usually an incorrect assumption. For the option strategist, this means that some of the things one might believe about certain option strategies having an advantage over certain *other* option strategies might be incorrect. In this chapter, a number of facts concerning stock price distribution will be brought to light, including how it might affect the option strategist.

MISCONCEPTIONS ABOUT VOLATILITY

Statistics are used to estimate stock price movement (and futures and indices as well) in many areas of financial analysis. Many authors have written extensively about the use of probabilities to aid in choosing viable option strategies. Stock mutual fund managers often use volatility estimates to help them determine how risky their portfolios are. The uses are myriad. Unfortunately, almost all of these applications are wrong! Perhaps *wrong* is too strong a word, but almost all estimates of stock price movement are overly conservative. This can be very dangerous if one is using such estimates for the purposes of, say, writing naked options or engaging in some other such strategy in which volatile stock price movement is undesirable.

As a review for those not familiar with mathematical distributions, the lognormal distribution is what's commonly used to describe stock prices because its shape is intuitively similar to the way stocks behave—they can't go below zero, they can rise to infinity, and most of the time they don't go much of anywhere. On top of that, the distribution's shape is based on the *historical volatility* of the underlying instrument. In a lognormal distribution (and normal distribution, too), stocks remain within 3 standard deviations of their current price 99.74% of the time. A standard deviation (sigma) is a statistical measure whose absolute distance grows larger with time, and it is something that can be easily calculated for any individual stock or futures contract, using historical prices.

There are great differences between the way stocks *really* behave and the assumptions that many mathematical models make about the way stocks *theoretically* behave. The problem lies in assuming that normal or lognormal distribution predicts stock price movements. Such an assumption does not allow for the occasional wild days that many stocks, some futures, and the relatively rare index undergo. The normal distribution pretty much says that a stock can't rise or fall by more than 3 standard deviations. In fact, according to math, the probability of something that behaves according to the normal distribution (the "classic" bell curve is a normal distribution) moving three standard deviations is 0.0013 (or just a little more than one tenth of one percent). So, if there are 2,500 optionable stocks, say, then one would expect maybe 3 of them to move three standard deviations on any given day.

However, in real market trading, there are routinely moves in stocks of more than 3 standard deviations—some as much as 5 standard deviations or more. Statistically (if the lognormal distribution were correct), one would only expect to see moves of that size maybe once in his lifetime, yet there are five or ten *each day*! Specifically, the normal distribution's probability of something being able to move 8 standard deviations is 0.000000000000000629. This number is so small that one would expect to see only one such occurrence in the known life of the universe, if prices were truly distributed via the normal distribution. If the normal distribution were the correct format for stock prices, such a small probability would indicate that one would not see an 8-standard deviation move until *billions* of trading days had passed. However, one can find several such moves on nearly any trading day, and it is not necessary to use some low-priced, oddball stock that dropped from 1 to .75 or some such nonsense as an example.

If those numbers don't convince you that stocks aren't lognormally distributed, perhaps the following study will. Table 38-1 lists moves that occurred on Monday, April 5, 1999—a day that was somewhat volatile (the Dow was up 174 points).

There were many other substantial moves that day. In the list in Table 38-1, all three that fell in price were on earnings warnings, and the two that rose were just swept up in that day's version of the Internet mania. All in all, 58 stocks had moves of greater than *four* standard deviations on that day! It was not any sort of special day, although it did fall

TABLE 38-1.

Stock	Last Sale	Change	Standard Deviations
Aspect Devt (ASDV)	8	–14.38	–31.2
Axent (ANT)	8	–12	–11.2
Ameritrade (AMTD)	91.63	+29.13	+8.6
CheckPoint (CHKP)	28.75	–10.75	–8.4
Sabre Gp. (TSG)	55	+8.50	+8.0

during earnings warnings season and in the midst of the Internet mania. But the fact that the market is somewhat volatile shouldn't justify all of these huge moves, if one still adheres to the belief that lognormal is the correct distribution.

So, just to make sure that wasn't a bad sample, a low-volatility period was chosen to sample. Since the inception of the CBOE's Volatility Index (VIX) trading, its lowest market volatility readings were in January and July of 1993. The lowest single day was July 25, 1993. On that day, *twelve* stocks had moves of more than four standard deviations. They included some big names, like Adaptec (ADPT), Bethlehem Steel (BS), U.S. Steel (X), Chiquita Brands (CQB), and Novell (NOVL).

The only way to tell how many standard deviations a stock has moved is to use its historical volatility—say, the 20-day historical volatility, for example—in the measurement. Thus, a 4-point move for a nonvolatile stock like Bethlehem Steel in 1993 pales in comparison to Ameritrade's 29-point gain in 1999 (Table 38-1), but both were large moves in terms of *standard deviations*, determined by using each stock's historical volatility.

As another test, prices from October 8, 1998—the day the market bottomed after a severe and rather swift decline brought on by Russian debt problems (it was a very volatile day after several volatile weeks of trading)—were tested to see how many stocks had moves of four standard deviations or more. There were 33, but that seemingly low number reflects the fact that many stocks' 20-day historical volatilities were already well inflated by October 8, 1998. On that day, the Utility Index (UTY) fell over 14 points, which was about 5.5 standard deviations. American Power Conversion (APCC) was *up* over six points that day, to 36.88—a *gain* of over five standard deviations.

Perhaps you might think that these one-day moves overstate things, that over a more prolonged period of time, the lognormal distribution fits better. A study was constructed to measure the volatility over a slightly longer time period. The results of the study not only confirmed our suspicions, but actually were somewhat startling in quantifying just how volatile certain individual issues can be.

The first example comprised the 30-day trading period between October 22, 1999, and December 7, 1999. There is nothing magical about these dates; that just happened to be the most recent 30-day period for which data was available when the study was conducted.

This particular period started out as a rather normal one in the market—in fact, prices had perhaps been a little less volatile than normal leading into that period. To support that statement, it should be noted that on October 22, the CBOE's Volatility Index (VIX) stood at about 23—a relatively middle-of-the-range level. So it wasn't as if this was an extremely volatile period.

The example is simple enough. The performance of 2,900 optionable stocks was measured to see if, beginning on October 22, 1999, any of them experienced moves of greater than three standard deviations at any time during the 30-day period. The standard deviation was based on the 20-day historical volatility of each individual stock. Obviously, a stock would have to make a much greater move to exceed the 3-standard deviation limit if it waited until the end of the 30-day period to do it, as opposed to making a big move on the first day. So, before reading on, take a guess: How many of the stocks do you think exceeded three standard deviation moves at some point during the 30 days? Remember that the lognormal distribution would predict virtually *no* moves of that size. The answer is in the next paragraph.

There were more stocks that had large upside moves than there were that had large downside moves over the period in question. That isn't too surprising, since the market moved up during that time. The final total showed this: Of the 2,900 stocks, nearly 650 experienced moves of 3 standard deviations or more during the life of the study, including 65 that moved more than six standard deviations. If the lognormal distribution were correct, the two lines in Table 38-2 would be filled with zeroes. This clearly shows stocks during this period didn't conform to the "normal" expectations. The study results are shown in Table 38-2. (Note that "σ" is the greek letter sigma, which mathematicians traditionally use to denote standard deviations, so 3σ means three standard deviations.)

TABLE 38-2.
Stock price movements.

Total Stocks: 2,888				Dates: 10/22/99–12/7/99	
	3σ	**4σ**	**5σ**	**>6σ**	**Total**
Upside Moves:	309	116	44	47	516
Downside Moves:	69	29	15	19	132
Total number of stocks moving >=3σ: 648 (22% of the stocks studied)					

The largest move was registered by a stock that jumped from a price of 5 to nearly 12 in about six trading days. One of the bigger downside movers was a stock that fell from about

20 to 8 in a matter of a couple of weeks, with most of the damage occurring in a two-day time period.

Lest you think that this example was biased by the fact that it was taken during a strong run in the NASDAQ market, here's another example, conducted with a different set of data—using stock prices between June 1 and July 18, 1999 (also 30 trading days in length). At that time, there were fewer large moves; about 250 stocks out of 2,500 or so had moves of more than three standard deviations. However, that's still one out of ten—way more than you've been led to expect if you believe in the normal distribution. The results are shown in Table 38-3.

Finally, one more example was conducted, using the least volatile period that we had in our database—July of 1993. Those results are in Table 38-4.

At first glance, it appears that the number of large stock moves diminished dramatically during this less volatile period in the market—until you realize that it still represents 10% of the stocks in the study. There were just a lot fewer stocks with listed options in 1993 than there were in 1999, so the database is smaller (it tracks only stocks with listed options). Once again, this means that there is a far greater chance for large standard deviations moves—about one in ten—than the nearly zero percent chance that the lognormal distribution would indicate.

TABLE 38-3.
More stock price movements.

Total Stocks: 2,447				Dates: 6/1/99–7/18/99	
	3σ	**4σ**	**5σ**	**>6σ**	**Total**
Upside Moves:	104	28	13	12	157
Downside Moves:	54	19	7	14	94
Total number of stocks moving >=3σ: 251 (10% of the stocks studied)					

TABLE 38-4.
Stock price movements during a nonvolatile period.

Total Stocks: 588				Dates: 7/1/93–8/17/93	
	3σ	**4σ**	**5σ**	**>6σ**	**Total**
Upside Moves:	14	5	1	1	21
Downside Moves:	28	5	3	4	40
Total number of stocks moving >=3σ: 61 (10% of the stocks studied)					

VOLATILITY BUYER'S RULE!

The point of the previous discussion is that stocks move a lot farther than you might expect. Moreover, when they make these moves, it tends to be with rapidity, generally including gap moves. There are not always gap moves, though, over a study of this length. Sometimes, there will be a more gradual transition. Consider the fact that one of the stocks in the study moved 5.8 sigma in the 30 days. There weren't any huge gaps during that time, but anyone who was short calls while the stock made its run surely didn't think it was a gradual advance.

So, what does this information mean to the average option trader? For one, you should certainly think twice about selling stock options in a potentially volatile market (or any market, for that matter, since these large moves are not by any means limited to the volatile market periods). This statement encompasses naked option selling, but also includes many forms of option selling, because of the possibilities of large moves by the underlying stocks.

For example, covered call writing is considered to be "conservative." However, when the stock has the potential to make these big moves, it will either cause one to give up large upside profits or to suffer large downside losses. (Covered call writing has limited profit potential and relatively large downside risk, as does its equivalent strategy, naked put selling.) When these large stock moves occur on the upside, a covered writer is often disappointed that he gave up too much of the upside profit potential. Conversely, if the stock drops quickly, and one is assigned on his naked put, he often no longer has much appetite for acquiring the stock (even though he said he "wouldn't mind" doing so when he sold the puts to begin with).

Even spreading has problems along these lines. For example, a vertical spread limits profits so that one can't participate in these relatively frequent large stock moves when they occur.

What can an option seller do? First, he must carefully analyze his position and allow for much larger stock movements than one would expect under the lognormal distribution. Also, he must be careful to sell options only when they are expensive in terms of implied volatility, so that any decrease in implied will work in his favor. Probably most judicious, though, is that an option seller should really concentrate on indices (or perhaps certain futures contracts), because they are statistically much less volatile than stocks. Hard as it is to believe, futures are less volatile than stocks (although the leverage available in futures can make them a riskier investment overall).

These examples of stock price movement are interesting, but are not rigorously complete enough to be able to substantiate the broad conclusion that stock prices don't behave lognormally. Thus, a more complete study was conducted. The following section presents the results of this research.

THE DISTRIBUTION OF STOCK PRICES

The earlier examples pointed out that, at least in those specific instances, stock price movements don't conform to the lognormal distribution, which is the distribution used in many mathematical models that are intended to describe the behavior of stock and option prices. This isn't new information to mathematicians; papers dating back to the mid-1960s have pointed out that the lognormal distribution is flawed. However, it isn't a terrible description of the way that stock prices behave, so many applications have continued to use the lognormal distribution.

Since 1987, the huge volatility that stocks have exhibited—especially on certain explosive down days such as the Crash of '87 or the mini-crash of April 14, 2000—has alerted more people to the fact that something is probably amiss in their usual assumptions about the way that stocks move. The lognormal distribution "says" that a stock really can't move farther than three standard deviations (whether it's in a day, a week, or a year). Actual stock price movements make a mockery of these assumptions, as stocks routinely move 4, 5, or even 10 standard deviations in a day (not all stocks, mind you, but some—many more than the lognormal distribution would allow for).

In order to further quantify these thoughts, computer programs were written to analyze our database of stock prices, going back over six years. As it turns out, that is a short period of time as far as the stock market is concerned. While it is certainly a long enough time to provide meaningful analysis (there are over 2.5 million individual stock "trading days" in the study), it is a biased period in that the market was rising for most of that time.

THE "BIG" PICTURE

The first part of the analysis shows that the total distribution of stock prices conforms pretty much to what the expectations were for the study, and—not surprisingly—to what others have written about the "real" distribution of stock prices. That is, there is a much greater chance of a large standard deviation move than the lognormal distribution would indicate. The high probabilities on the ends of the distribution are called "fat tails" by most mathematicians and stock market practitioners alike. These "tails" are what get option writers in trouble—and perhaps even leveraged stock owners—because margin buyers and naked writers figure that they will never occur. It is not intuitively obvious to them and to many other stock market participants that stock prices behave in this manner.

The graphs in Figure 38-1 show this total distribution. The top graph is that of the lognormal distribution and the actual distribution, using the data from September 1993 to April 2000—overlaid upon each other. The actual distribution was drawn using 30-day moves (i.e., the number of standard deviations was computed by looking at the stock price on a certain day, and then where it was 30 calendar days later). The x-axis (bottom axis) shows the number of standard deviations moved. Note that the curves have the shape of a *normal* distribution rather than a *lognormal* distribution, because the x-axis denotes number of standard deviations moved rather than stock prices themselves. For this reason, the term "normal" will be used in the remainder of this section; it should be understood that it is the distribution of standard deviations that is "normal," while the distribution of the stock prices measured by those standard deviation moves is "lognormal." The y-axis (left axis) shows the "count"—the number of times out of the 2.5 million data points computed that each point on the x-axis actually occurred (in the case of the "actual" distribution) or could be expected to occur (in the case of the "normal" distribution). The notation on the y-axis shows the actual count divided by 10. So, for example, the highest point (0 standard deviations moved) for the "normal" distribution shows that about 95,000 times out of 2.5 million, you could expect a stock to be unchanged at the end of 30 calendar days.

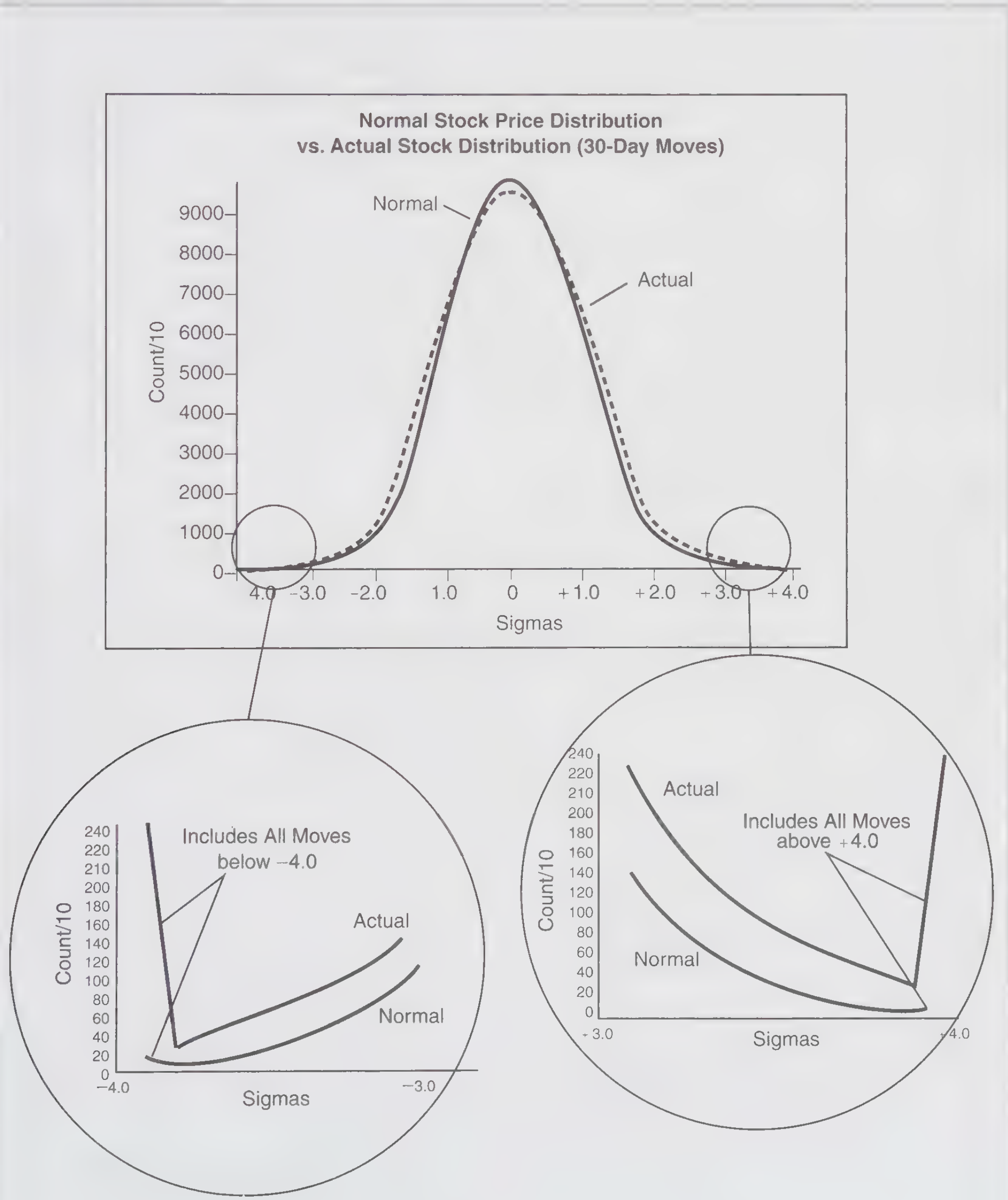
At first glance, it appears that the two curves have almost identical shapes. Upon closer inspection, however, it is clear that they do not, and in fact some rather startling differences are evident.

Fat Tails

Figure 38-1 shows the fat tails quite clearly. Magnified views of the fat tails are provided to show you the stark differences between the theoretical ("normal") distribution and actual stock price movements. Consider the downside (the lower left circled graph in Figure 38-1). First, note that both the "actual" and "normal" graphs lift up at the end—the leftmost point. This is because the graph was terminated at –4.0 standard deviations, and all moves that were greater than that were accumulated and graphed as the leftmost data point. You can see that the "normal" distribution expects fewer than 200 moves out of 2.5 million to be of –4.0 standard deviations or more (yes, the "normal" distribution *does* allow for moves greater than 3 standard deviations; they just aren't very probable). On the other hand, actual stock prices—even during the bull market that was occurring during the term of the data in this study—fell more than –4.0 standard deviations nearly 2,500 times out of 2.5 million. Thus, in reality, there was really more than 12 times the chance (2,500 vs. 200) that stocks could suffer a severely dramatic fall, when comparing actual to theoretical distribution. Also notice in that lower left circle that the actual distribution is greater than the normal distribution all along the graph.

The upside fat tail shows much the same thing: Actual stock prices can rise farther than the normal distribution would indicate. At the extreme—moves of +4.0 standard deviations or more—there were about 2,000 such moves in actual stock prices, compared with fewer than 100 expected by the normal distribution. Again, a very large discrepancy: twenty-to-one.

FIGURE 38-1.
Stock price distribution is not "normal."



Inflection Points

If the actual distribution is higher at both ends, it must be lower than the normal distribution *somewhere*, because there are only a total of 2.5 million data points plotted. It turns out in this case that the normal distribution is higher (i.e., is expected to occur more often than it actually does) between –2.5 standard deviations and +0.5 standard deviations. Those are the points where the two curves cross over each other—the inflection points. Outside of that range, the actual distribution is more frequent than it was expected to be.

It is probably the case that this data reflected an overly bullish period. That is, actual stock prices rose farther than they were expected to, not necessarily at the tails, but in the intermediate ranges, say between +0.5 and +1.5 standard deviations. This does not change the results of the study as far as the tails go, but one may not always be able to count on intermediate upside moves being more frequent than predicted.

SIDE BENEFITS OF THIS STUDY

In the course of doing these analyses, a lot of smaller distributions were calculated along the way. One of these is the distribution on any individual trading day that was involved in the study. Now, one must understand that one day's trading yields only about 3,000 data points (there were about 3,000 stocks in the database), so the resulting curve is not going to be as smooth as the ones shown in Figure 38-1. Nevertheless, some days could be interesting. For example, consider the day of the mini-crash, Friday, April 14, 2000. The Dow-Jones Industrials were down 617 that day; the S&P 500 index was down 83 points; and the NASDAQ-100 was down 346. Except for the Crash of 1987, these were the largest single-day declines in history at the time. The distribution graph is shown in Figure 38-2.

First of all, notice how heavily the distribution is skewed to the left; that agrees with one's intuition that the distribution should be on the left when there is such a serious down day as 4/14/2000. Also, notice that the leftmost data point—representing all moves of –4.0 standard deviations and lower, shows that about 750 out of the 2,984 stocks had moves of that size! That is unbelievable, and it really points out just how dangerous naked puts and long stock on margin can be on days like this. No probability calculator is going to give much likelihood to a day like this occurring, but it *did* occur and it benefited those holding long puts greatly, while it seriously hurt others.

In addition to distributions for individual dates, distributions for individual stocks were created for the time period in question. The graph for IBM, using data from the same study as above (September 1993 to April 2000) is shown in Figure 38-3. In the next graph, Figure 38-4, a longer price history of IBM is used to draw the distribution: 1987 to 2000. Both graphs depict 30-day movements in IBM.

FIGURE 38-2.
Stock price distribution for 4/14/2000 – 2,984 Stocks in Study.

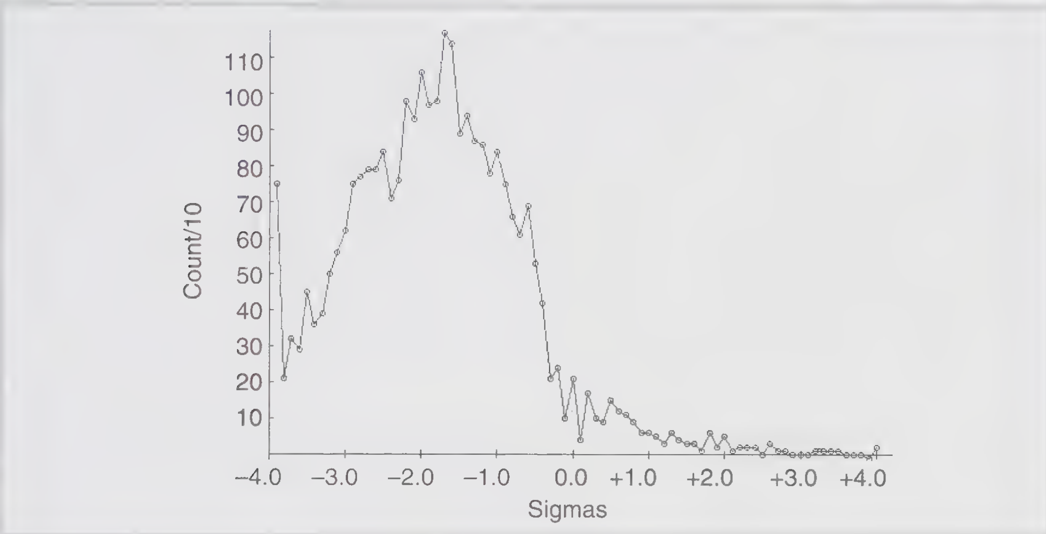


FIGURE 38-3.
Stock price distribution, IBM, 7-year.

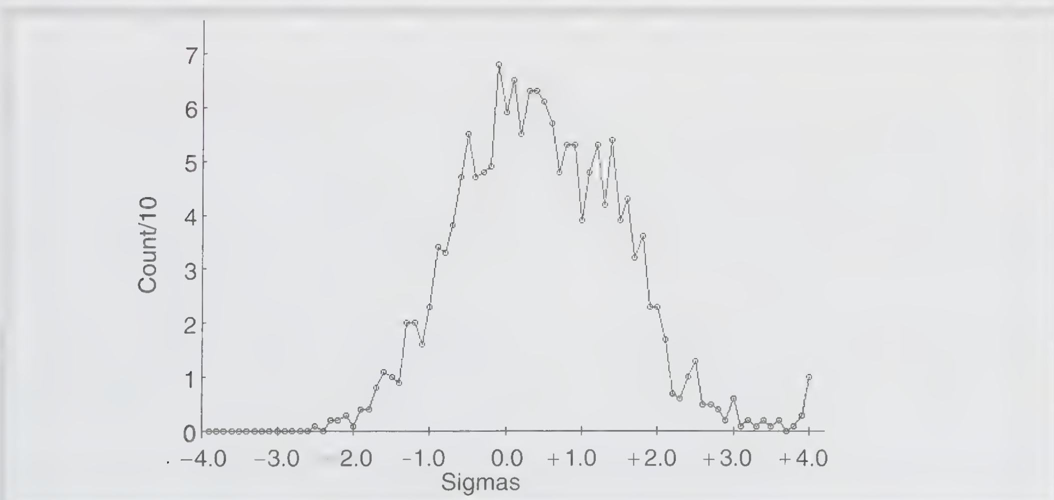
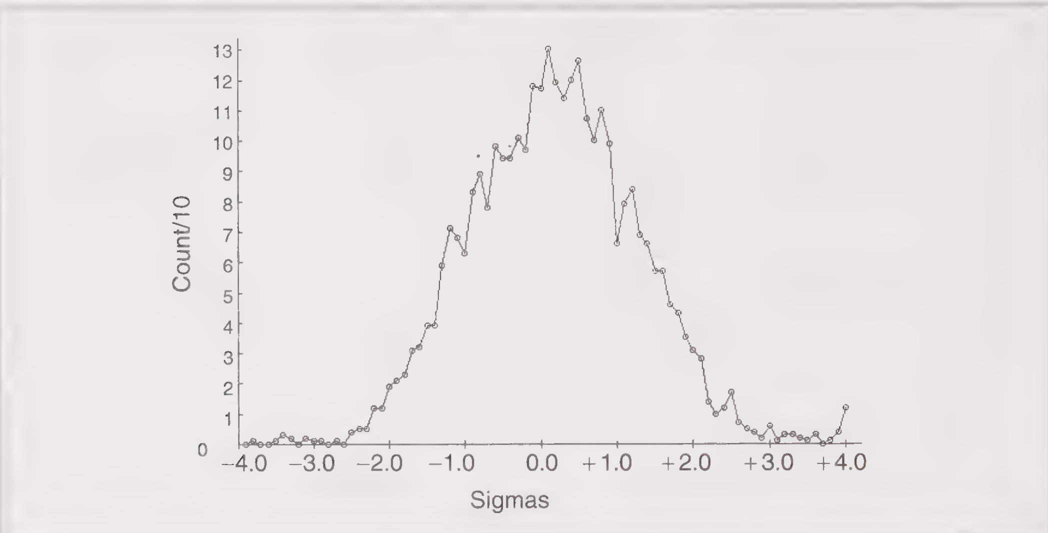


Figure 38-3 perhaps shows even more starkly how the bull market affected things over the six-plus year period, from 1993 to 2000. There are over 1,600 data points for IBM (i.e., daily readings) in Figure 38-3, yet the whole distribution is skewed to the right. It apparently was able to move up quite easily throughout this time period. In fact, the worst

FIGURE 38-4.
Actual stock price distribution, IBM, 13-year.



move that occurred was *one* move of −2.5 standard deviations, while there were about *ten* moves of +4.0 standard deviations or more.

For a longer-term look at how IBM behaves, consider the longer-term distribution of IBM prices, going back to March 1987, as shown in Figure 38-4.

From Figure 38-4, it's clear that this longer-term distribution conforms more closely to the normal distribution in that it has a sort of symmetrical look, as opposed to Figure 38-3, which is clearly biased to the right (upside).

These two graphs have implications for the big picture study shown in Figure 38-1. The database used for this study had data for most stocks only going back to 1993 (IBM is one of the exceptions); but if the broad study of all stocks were run using data all the way back to 1987, it is certain that the "actual" price distribution would be more evenly centered, as opposed to its justification to the right (upside). That's because there would be more bearish periods in the longer study (1987, 1989, and 1990 all had some rather nasty periods). Still, this doesn't detract from the basic premise that stocks can move farther than the normal distribution would indicate.

WHAT THIS MEANS FOR OPTION TRADERS

The most obvious thing that an option trader can learn from these distributions and studies is that buying options is probably a lot more feasible than conventional wisdom would have you believe. The old thinking that selling an option is "best" because it wastes away every day is false. In reality, when you have sold an option, you are exposed to adverse price movements and adverse movements in implied volatility all during the life of the option. The likelihood of those occurring is great, and they generally have more influence on the price of the option in the short run than does time decay.

You might ask, "But doesn't all the volatility in 1999 and 2000 just distort the figures, making the big moves more likely than they ever were, and possibly ever will be again?" The answer to that is a resounding, "No!" The reason is that the *current* 20-day historical volatility was used on each day of the study in order to determine how many standard deviations each stock moved. So, in 1999 and 2000, that historical volatility was a high number and it therefore means that the stock would have had to move a very long way to move four standard deviations. In 1993, however, when the market was in the doldrums, historical volatility was low, and so a much smaller move was needed to register a 4-standard deviation move. To see a specific example of how this works in actual practice, look carefully at the chart of IBM in Figure 38-4, the one that encompasses the crash of '87. Don't you think it's a little strange that the chart doesn't show any moves of greater than minus 4.0 standard deviations? The reason is that IBM's historical volatility had already increased so much in the days preceding the crash day itself, that when IBM fell on the day of the crash, its move was *less* than minus 4.0 standard deviations. (Actually, its one-day move was greater than –4 standard deviations, but the 30-day move—which is what the graphs in Figure 38-3 and 38-4 depict—was not.)

STOCK PRICE DISTRIBUTION SUMMARY

One can say with a great deal of certainty that stocks do *not* conform to the normal distribution. Actually, the normal distribution is a decent approximation of stock price movement *most* of the time, but it's these "outlying" results that can hurt anyone using it as a basis for a nonvolatility strategy.

Scientists working on chaos theory have been trying to get a better handle on this. An article in *Scientific American* magazine ("A Fractal Walk Down Wall Street," February 1999 issue) met some criticism from followers of Elliott Wave theory, in that they claim the article's author is purporting to have "invented" things that R. N. Elliott discovered years ago. I don't know about that, but I do know that the article addresses these same points in more detail. In the article, the author points out that chaos theory was applied to the prediction of earthquakes. Essentially, it concluded that earthquakes can't be predicted. Is this therefore a useless analysis? No, says the author. It means that humans should concentrate on building stronger buildings that can withstand the earthquakes, for no one can predict when they may occur. Relating this to the option market, this means that one should concentrate on building strategies that can withstand the chaotic movements that occasionally occur, since chaotic stock price behavior can't be predicted either.

It is important that option traders, above all people, understand the risks of making too conservative an estimate of stock price movement. These risks are especially great for the writer of an option (and that includes covered writers and spreaders, who may be giving away too much upside by writing a call against long stock or long calls). By quantifying past stock price movements, as has been done in this chapter, my aim is to convince you that "conventional" assumptions are not good enough for your analyses. This doesn't mean that it's okay to buy overpriced options just because stocks can make large moves with a greater frequency than most option models predict; but it certainly means that the buyer of underpriced options stands to benefit in a couple of ways. Conversely, an option seller must certainly concentrate his efforts where options are expensive, and even then should be acutely aware that he may experience larger-than-expected stock price movements while the option position is in place.

So what does this mean for option strategies? On the surface, it means that if one uses the normal (or lognormal) distribution for estimating the probability of a strategy's success, he *may* get a big move in the stock that he didn't originally view as possible. If one were long straddles, that's great. However, if he is short naked options, then there could be a nasty surprise in store. That's one reason why extreme caution should be used regarding selling naked options on stocks; they can make moves of this sort too often. At least with indices, such moves are far less frequent, although the Dow drop of over 550 points in October 1997 was a move of seven standard deviations, and the crash of '87 was about a 16-standard deviation move—which Professor Mark Rubenstein of the University of California at Berkeley says was something that should occur about once in *ten times the life of our current universe!* That's according to lognormal distribution, of course, which we know understates things somewhat, but it's still a big number under any distribution.

There are two approaches that one can take, then, regarding option strategies. One is to invent another method for estimating stock price distributions. Suffice it to say that that is not an easy task, or someone would have made it well-known already. There have been many attempts, including some in which a large history of stock price movements is observed and then a distribution is fitted to them. The problem with accounting for these occasional large price moves is that it is perhaps an even more grievous error to *overestimate* the probabilities of such moves than to underestimate them.

The second approach is to continue to use the normal distribution, because it's fast and accessible in a lot of places. Then, either rely on option buying strategies (straddles, for example) where implied volatility appears to be low—knowing that you have a chance at better results than the statistics might indicate—or adjust your calculations mentally for these large potential movements if you are using option selling strategies.

THE PRICING OF OPTIONS

The extreme movements of the fat tail distribution should be figured into the pricing of an option, but they really are not, at least not by most models. The Black–Scholes model, for example, uses a lognormal distribution. Personally, this author believes that the Black–Scholes model is an excellent tool for analyzing options and option strategies, but one must understand that it may not be affording enough probability to large moves by the underlying.

Does this mean that most options are underpriced, since traders and market-makers are using the Black–Scholes model (or similar models) to price them? Without getting too technical, the answer is that yes, some options—particularly out-of-the-money options—are probably underpriced. However, one must understand that it is still a relatively rare occurrence to experience one of these big moves—it's just not as rare as the lognormal distribution would indicate. So, an out-of-the-money option might be *slightly* underpriced, but often not enough to make any real difference.

In fact, *futures* options in grains, gold, oil, and other markets that often experience large and sudden rallies display a distinct volatility skew. That is, out-of-the-money *call* options trade at significantly higher implied volatilities than do at-the-money options. Ironically, there is far less chance of one of these hyper-standard-deviation moves occurring in commodities than there is in stocks, at least if history is a guide. So, the fact that some out-of-the-money futures options are expensive is probably an incorrect *over*adjustment for the possibility of large moves.

THE PROBABILITY OF STOCK PRICE MOVEMENT

The distribution information introduced in this chapter can be incorporated into somewhat rigorous methods of determining probabilities. That is, one can attempt to assess the chances of a stock, futures contract, or index moving by a given distance, and those chances can incorporate the fat tails or other *non*-lognormal behavior of prices.

The software that calculates such probabilities is typically named a "probability calculator." There are many such software programs available in the marketplace. They range from free calculators to completely overpriced ones selling for more than $1,000. In reality, high-level probability calculation software can be created by someone with a good understanding of statistics, or a program can be purchased for a rather nominal fee—perhaps $100 or so.

Before getting into these various methods of probability estimation, it should be noted that all of them require the trader to input a volatility estimate. There are only a few other inputs, usually the stock price, target price(s), and length of time of the study.

The volatility one inputs is, of course, an estimate of *future* volatility—something that cannot be predicted with certainty. Nevertheless, any probability calculator requires this input. So, one must understand that the results one obtains from any of these probability calculators is an estimate of what might happen. It should not be relied on as "gospel."

Additionally, probability calculators make a second assumption: that the volatility one inputs will remain constant over the entire length of the study. We *know* this is incorrect, for volatility can change daily. However, there really isn't a good way of estimating how volatility might change in the course of the study, so we are pretty much forced to live with this incorrect assumption as well.

There is no certain way to mitigate these volatility "problems" as far as the probability calculator is concerned, but one helpful technique is to bias the volatility projection *against* your objectives. That is, be overly conservative in your volatility projections. If things turn out to be better than you estimated, fine. However, at least you won't be overstating things initially. An example may help to demonstrate this technique.

Example: Suppose that a trader is considering buying a straddle on XYZ. The five-month straddle is selling for a price of 8, with the stock currently trading near 40. A probability calculator will help him to determine the chances that XYZ can rise to 48 or fall to 32 (the break-even points) prior to the options' expiration. However, the probability calculator's answer will depend heavily on the volatility estimate that the trader plugs into the probability calculator. Suppose that the following information is known about the historical volatility of XYZ:

10-day historical volatility:	22%
20-day historical volatility:	20%
50-day historical volatility:	28%
100-day historical volatility	33%

Which volatility should the trader use? Should he choose the 100-day historical volatility since this is a five-month straddle, which encompasses just about 100 trading days until expiration? Should he use the 20-day historical volatility, since that is the "generally accepted" measure that most traders refer to? Should he calculate a historical volatility based *exactly* on the number of days until expiration and use that?

To be most conservative, *none* of those answers is right, at least not for the right reasons. Since one is buying options in this strategy, he should use the *lowest* of the above historical volatility measures as his volatility estimate. By doing so, he is taking a conservative approach. If the straddle buy looks good under this conservative assumption, then he can feel fairly certain that he has not overstated the possibilities of success. If it turns out that volatility is *higher* during the life of the position, that will be an added benefit to this position consisting of long options. So, in this example, he should use the 20-day historical volatility *because it is the lowest of the four choices that he has.*

Similarly, if one is considering the sale of options or is taking a position with a negative vega (one that will be harmed if volatility increases), then he should use the *highest* historical volatility when making his probability projections. By so doing, he is again being conservative. If the strategy in question still looks good, even under an assumption of high volatility, then he can figure that he won't be unpleasantly surprised by a higher volatility during the life of the position.

There have been times when a 100-day lookback period was not sufficient for determining historical volatility. That is, the underlying has been performing in an erratic or unusual manner for over 100 days. In reality, its true nature is not described by its movements over the past 100 days. Some might say that 100 days is not enough time to determine the historical volatility in any case, although most of the time the four volatility measures shown above will be a sufficient guide for volatility.

When a longer lookback period is required, there is another method that can be used: Go back in a historical database of prices for the underlying and compute the 20-day, 50-day, and 100-day historical volatilities for *all* the time periods in the database, or at least during a fairly large segment of the past prices. Then use the *median* of those calculations for your volatility estimates.

Example: XYZ has been behaving erratically for several months, due to overall market volatility being high as well as to a series of chaotic news events that have been affecting XYZ. A trader wants to trade XYZ's options, but needs a good estimate of the "true" volatility potential of XYZ, for he thinks that the news events are out of the way now. At the current time, the historical volatility readings are:

20-day historical:	130%
50-day historical	100%
100-day historical	80%

However, when the trader looks farther back in XYZ's trading history, he sees that it is not normally this volatile. Since he suspects that XYZ's recent trading history is not typical of its true long-term performance, what volatility should he use in either an option model or a probability calculator?

Rather than just using the maximum or minimum of the above three numbers (depending on whether one is buying or selling options), the trader decides to look back over the last 1,000 trading days for XYZ. A 100-day historical volatility can be computed, using 100 consecutive trading days of data, for 901 of those days (beginning with the 100th day and continuing through the 1,000th day, which is presumably the current trading day). Admittedly, these are not completely unique time periods; there would only be ten non-overlapping (independent) consecutive 100-day periods in 1,000 days of data. However, let's assume that the 901 periods are used. One can then arrive at a *distribution* of 100-day historical volatilities. Suppose it looks something like this:

Percentile	100-Day Historical
0th	34%
10th	37%
20th	43%
30th	45%
40th	46%
50th	48%
60th	51%
70th	58%
80th	67%
90th	75%
100th	81%

In other words, the 901 historical volatilities (100 days in each) are sorted and then the percentiles are determined. The above table is just a snapshot of where the percentiles lie. The range of those 901 volatilities is from 34% on the low side to 81% on the high side. Notice also that there is a very flat grouping from about the 20th percentile to the 60th percentile: The 100-day historical volatility was between 43% and 51% over that entire range. The *median* of the above figures is 48%—the 100-day volatility at the 50th percentile.

Referring to the early part of this example, the current 100-day historical is 80%, a very high reading in comparison to what the measures were over the past 1,000 days, and certainly much higher than the median of 48%.

One could perform similar analyses on the 1,000 days of historical data to determine where the 10-day, 20-day, and 50-day historical volatilities were over that time. Those, too, could be sorted and arranged in percentile format, using the 50th percentile (median) as a good estimate of volatility. After such computations, the trader might then have this information:

Using 1,000 days of data:

Median 100-day historical volatility: 48%
Median 50-day historical volatility: 49%
Median 20-day historical volatility: 52%
Median 10-day historical volatility: 49%

If these were all the data that one had, then he would probably use a volatility estimate of 48% or so in his option models or probability calculators. Of course, this is starkly different from the current levels of historical volatility (shown at the beginning of this example). So, one must be careful in assessing whether he expects the stock to perform more in line with its longer-term (1,000 trading days) characteristics or if there is some reason to think that the stock's behavior patterns have changed and the higher, more recent volatilities should be used.

The pertinent volatilities to consider, then, in a strategy analysis are the medians as well as the current figures. If the trader were going to be buying options in his strategy, should he use the minimum of the volatilities shown, 48%? Probably. However, if he's a seller of options, should he use the maximum, 130%? That might be a little *too* much of a penalty, but at least he would feel safe that if his volatility selling position had a positive expected return with that high a volatility projection, then it must truly be an attractive position.

In an analysis like that shown in this example, there is nothing magical about using 1,000 trading days. Perhaps something like 600 trading days would be better. The idea is to use enough trading days to bring in some historic data to counterbalance the recent, erratic behavior of the stock.

Among other things, this example also shows that volatilities are unstable, no matter how much work and mathematics one puts into calculating them. Therefore, they are at best a fragile estimate of what might happen in the future. Still, it's the best guess that one can make. The trader should realize, though, that when volatilities are this disparate when comparing recent and more distant activity, the results of any mathematical projections using those volatilities should not be relied upon too heavily. Those results will be just as tenuous as the volatility projections themselves.

Of course, in any case, the actual volatility that occurs while the position is in place may be even more unfavorable than the one the trader used in his initial analysis. There is nothing that one can do about that. But if you choose what appears to be a somewhat unfavorable volatility, and the position still looks good under those assumptions, then it is likely that the trader will be pleasantly surprised more often than not—that actual volatility during the life of the position will tend to be more in his favor than not.

In a recent chapter, the various methods of trying to predict volatility were outlined, using either historical volatility, implied volatility, a moving average of either of those, or even GARCH volatility. None of these will predict with certainty what is going to happen in the future. Hence, the prediction of volatility is necessarily vague at best.

In addition to the vagaries of estimating volatility, the probability calculators will return an answer that represents the probability of something happening "in the long run." That is, if the same scenario were to arise many, many times, the answer is relevant to how many times the stock would move to the indicated target price. This is small solace if one happens to be caught in the vortex of the Crash of '87, for example. So, just remember that these probability calculators are tools that can help you in assessing the relative risks of similar positions (evaluating various naked option sales, say), but the resulting stock movement in any one case can be quite different from what any probability calculator describes as the chances of that move actually happening.

THE ENDPOINT CALCULATION

The following paragraphs describe how the various probability calculation mechanisms work. The simplest and most straightforward probability calculation has already been presented in Chapter 28 on mathematical applications. It was included in the section on "expected returns" in that chapter. The formula is presented here again, for completeness.

The formula gives the probability of a stock, which is currently at price p, being below some other price, q, at the end of the time period. The lognormal distribution is assumed.

Probability of stock being below price q at end of time period, t

$$P(\text{below}) = N\left(\frac{\ln\left(\frac{q}{p}\right)}{v_t}\right)$$

where

N = cumulative normal distribution

p = current price of the stock

q = price in question

ln = natural logarithm for the time period in question

If one is interested in computing the probability of the stock being above the given price, the formula is

$$P(\text{above}) = 1 - P(\text{below})$$

In the above formula, $v_t = v\sqrt{t}$ where t is time to expiration in years and v is annual volatility, as usual.

This formula is quite elementary for predictive purposes, and it is used by many traders. This calculator can be found for free at the website www.optionstrategist.com. Its main problem is that it gives the probability of the stock being above or below the target price *at the end of the time period*, t. That's not a totally realistic way of approaching probability analysis. Most option traders are very concerned with what happens to their positions *during* the life of the option, not just at expiration.

Example: Suppose a trader is a seller of naked put options. He sells OEX October 550 puts naked, with OEX currently trading at 600. He would not normally just walk away from this position until October expiration, because of the large risk involved with the sale of a naked option. There are essentially three scenarios that can occur:

1. OEX might *never* fall to 550 by expiration. In this case, he would have a very comfortable trade that was never in jeopardy, and the options would expire worthless.
2. OEX might fall below 550 and remain there until expiration. In this case, he would surely have a loss unless OEX were just a tiny bit below 550.
3. OEX might fall below 550 at some time between when the trade was established and when expiration occurred, but then subsequently rally back above 550 by the time expiration arrived.

An experienced option trader would almost certainly adjust if scenario 3 arose, in order to prevent large losses from occurring. He might roll his naked puts down and out to another strike, or he might just close them out altogether. However, it is unlikely that he would do *nothing*.

The simple probability calculator formula shown above does *not* take into account the trader's third scenario. Since it is only concerned with where the stock is at expiration of the options, only scenarios 1 and 2 apply to it. Hence the usage of this simple calculator is not really descriptive of what might happen to a trade *during* its lifetime.

Let's assign some numbers to the above trade, so that you might see the difference. Suppose that the volatility estimate is 25%, there are 30 days until expiration, and the prices are as stated in the previous example: OEX is at 600, and the striking price of the naked put being sold is 550. The resulting probabilities might be something like this:

Scenario	Actual Probability of Occurrence
1. OEX never falls below 550	67%
2. OEX falls below 550 and remains there	19%
3. OEX falls below 550 but rallies later	14%

The probabilities stated above are the "real" probabilities of the three various scenarios occurring. However, if one were using the simple probability calculator presented above, he would only have the following information:

Probability of OEX being above 550 at expiration: 81%
Probability of OEX being below 550 at expiration: 19%

So, with the simple calculator, it looks like there's an 81% chance of a worry-free trade. Just sit back and relax and let the option expire worthless. However, in real life—as shown by the previous set of probabilities, there's only a 67% chance of a worry-free trade. The difference—the other 14%—is the probability of the third scenario occurring (OEX falls below 550, but rallies back above it by expiration). The simple probability calculator doesn't account for that scenario at all.

Hence, most serious traders don't use the simple model. Does that mean it's not useful at all? No, it is certainly viable as a comparative tool; for example, to compare the chances of the OEX put expiring worthless versus those of another put sale being considered, perhaps something in a stock option. However, better analyses can be undertaken.

Before leaving the scenario of the simple probability calculator, one more point should be made. It has been mentioned earlier in this book that the delta of an option is actually a fairly good estimate of the probability of the option being in-the-money at its expiration date. Thus, the delta and the simple endpoint probability calculator shown above attempt to convey the same information to a trader. In reality, because of the fact that implied volatility might be different for various strikes (a volatility skew), especially in index options, the delta of the option might not agree exactly with the probability calculator. Even so, the delta is a quick and dirty way of estimating the probability of the stock being above the strike price (in the case of call options) or below the strike price (in the case of put options) at expiration.

THE "EVER" CALCULATOR

Having seen the frailties of the endpoint calculator, the next step is to try to design a calculator that can estimate the probability of the stock *ever* hitting the target price(s) *at any time* during the life of the probability study, usually the life of an option. It turns out that there are a couple of ways to approach this problem. One is with a Monte Carlo analysis, whereby one lets a computer run a large number of randomly generated scenarios (say, 100,000 or so) and counts the number of times the target price is hit. A Monte Carlo analysis is a completely valid way of estimating the probability of an event, but it is a somewhat complicated approach.

In reality, there is a way to create a single formula that can estimate the "ever" probability, although it is not any easy task either. In the following discussion, I am borrowing liberally from correspondence with Dr. Stewart Mayhew, Professor of Mathematics at the University of Georgia. For proprietary reasons, the exact formula is not given here, but the following description should be sufficient for a mathematics or statistics major to encode it. If one is not interested in implementing the actual formula, the calculation can be obtained through programs sold by McMillan Analysis Corp. at www.optionstrategist.com.

This discussion is quite technical, so readers not interested in the description of the mathematics can skip the next paragraph and instead move ahead to the next section on Monte Carlo studies.

These are the steps necessary in determining the formula for the "ever" probability of a stock hitting an upside target at any time during its life. First, make the assumption that stock prices behave randomly, and perform at the risk-free rate, r. Mathematicians call random behavior "Brownian motion." There are a number of formulae available in statistics books regarding Brownian motion. If one is to estimate the probability of reaching a maximum (upside target) point, what is needed is the known formula for the *cumulative density function (CDF)* for a running maximum of a Brownian motion. In that formula, it is necessary to use the lognormal function to describe the upside target. Thus, instead of using the actual target price in the CDF formula, one substitutes $In(q/p)$, where q is the target price and p is the current stock price.

The "ever" probability calculator provides much more useful information to a trader of options. Not only does a naked option seller have a much more realistic estimate of the probability that he's going to have to make an adjustment during the life of an option, but the option buyer can find the information useful as well. For example, if one is buying an option at a price of 10, say, then he could use the "ever" probability calculator to estimate the chances of the stock trading 10 points above the striking price at any time during the life of the option. That is, what are the chances that the option is going to at least break even? The option buyer can, of course, determine other things too, such as the probability that the option doubles in price (or reaches some other return on investment, such as he might deem appropriate for his analysis).

THE MONTE CARLO PROBABILITY CALCULATOR

Up to this point, the calculators we have discussed are subject to the limitations described earlier—mainly, that they rely heavily on one's volatility estimate, that they assume the volatility will remain constant over time, and that they assume a lognormal distribution. The early part of this chapter was spent explaining that the lognormal distribution is *not* the real distribution that stock prices adhere to. So, what we'd like to see in a probability calculator is one that could adjust for various volatility scenarios as time passed and one in which the assumed distribution of stock prices was *not* lognormal.

When one starts to make these sorts of assumptions, I do not believe there is a single formula that can be derived for the probability calculations. Rather, what is known as a Monte Carlo simulation must be undertaken. Essentially, one "tells" the computer what he is trying to simulate. It could be any number of things in real life, perhaps the rocket engine components in a NASA space shuttle, or the operation of an internal combustion engine, or the movement of a stock. As long as the process can be described, it can be simulated by a computer. Then, the computer can run a large number of those simulations to determine the answers to such things as "What is the failure rate of the NASA engine components?" or "How long can the internal combustion engine go without an oil change?" or "What is the probability of the stock trading at a certain target price?" The Monte Carlo simulation technique can be thought of as letting the computer run through the simulation a *lot* of times and counting how many times a certain outcome occurs. If the number of trials (simulations) is large enough and the model is good enough, then the resulting count divided by the number of trials undertaken is a good probability estimate of the said event occurring. The reason one runs a lot of trials is that over a large number of trials, the frequency with which an event occurs will approximate the actual probability of its occurrence for a single trial—the single trial being your trade, for example.

The next three paragraphs describe the general process necessary for constructing a stock probability calculator using a Monte Carlo simulation. Again, this is fairly technical, so if the reader is not interested in the background behind the mathematics, then skip ahead three paragraphs. In the case of a stock probability calculator, the Monte Carlo simulation can be undertaken as follows.

We know what the distribution of stock prices looks like. The fat tails can be built into the distribution if one wants to simulate real life. See Figure 38-1 for both the lognormal distribution and the actual distribution. It's a simple matter to tell the computer this information. For example, recall that 2.5 million points went into making up Figure 38-1. In the actual distribution in Figure 38-1, about 92,000 (or 3.68%) of them resulted in the stock being unchanged. Also, only about 2,500 of them, or 1/10th of one percent, resulted in a move of −4.0 standard deviations or more. Those percentages, along with all of the others, would be built into the computer, so that the total distribution accounts for 100% of all possible stock movements.

Then, we tell the computer to allow a stock to move randomly in accordance with whatever volatility the user has input. So, there would be a fairly large probability that it wouldn't move very far on a given day, and a very small probability that it would move three or more standard deviations. Of course, with the fat tail distribution, there would be a larger probability of a movement of three or more standard deviations than there would be with the regular lognormal distribution. The Monte Carlo simulation progresses through the given number of trading days, moving the stock cumulatively as time passes. If the stock hits the break-even price, that particular simulation can be terminated and the next one begun. At the end of all the trials (100,000 perhaps), the number in which the upside target was touched is divided by the total number of trials to give the probability estimate.

Is it really worth all this extra trouble to evaluate these more complicated probability distributions? It seems so. Consider the following example:

Example: Suppose that a trader is considering selling naked puts on XYZ stock, which is currently trading at a price of 80. He wants to sell the November 60 puts, which expire in two months. Although XYZ is a fairly volatile stock, he feels that he wouldn't mind owning it if it were put to him. However, he would like to see the puts expire worthless. Suppose the following information is available to him via the various probability calculators:

Simple "end point" probability of XYZ < 60 at expiration:	10%
Probability that XYZ *ever* trades < 60 (using the lognormal distribution):	20%
Probability that XYZ *ever* trades < 60 (using the fat tail distribution):	22%

If the chances of the put never needing attention were truly only 10%, this trader would probably sell the puts naked and feel quite comfortable that he had a trade that he wouldn't have to worry too much about later on. However, if the *true* probability that the put will need attention is 22%, then he might *not* take the trade. Many naked option sellers try to sell options that have only probabilities of 15% or less of potentially becoming troublesome.

Hence, the choice of which probability calculation he uses can make a difference in whether or not a trade is established.

Other strategies lend themselves quite well to probability analysis as well. Credit spreaders—sellers of out-of-the-money put spreads—usually attempt to quantify the probability of having to take defensive action. Any action to adjust or remove a deeply out-of-the-money put credit spread usually destroys most or all of its profitability, so an accurate initial assessment of the probabilities of having to make such an adjustment is important.

Option buyers, too, would benefit from the use of a more accurate probability estimate. This is especially true for neutral strategies, such as straddle or strangle buying, when the trader is interested in the chances of the stock being able to move far enough to hit one or the other of the straddle's break-even points at *some* time during the life of the straddle.

The Monte Carlo probability calculation can be expanded to include other sorts of distributions. In the world of statistics, there are many distributions that define random patterns. The lognormal distribution is but one of them (although it is the one that most closely follows stock prices movements in general). Also, there is a school of thought that says that each stock's individual price distribution patterns should be analyzed when looking at strategies on that stock, as opposed to using a general stock price distribution accumulated over the entire market. There is much debate about that, because an individual stock's trading pattern can change abruptly; just consider any of the Internet stocks in the late 1990s and early 2000s. Thus, a probability estimate based on a single stock's behavior, even if that behavior extends back several years, might be too unreliable a statistic upon which to base a probability estimate.

In summary, then, one *should* use a probability calculator before taking an option position, even an outright option buy. Perhaps straight stock traders should use a probability calcutor as well. In doing so, though, one should be aware of the limitations of the estimate: It is heavily biased by the volatility estimate that is input and by the assumption of what distribution the underlying instrument will adhere to during the life of the position. While neither of those limitations can be overcome completely, one can mitigate the problems by using a conservative volatility estimate. Also, he can look at the results of the probability calculation under several distributions (perhaps lognormal, fat tail, and the distribution using only the past price behavior of the underlying instrument in question) and see how they differ. In that case, he would at least have a feeling for what *could* happen during the life of the option position.

EXPECTED RETURN

The concept of expected return was described in the chapter on mathematical applications. In short, expected return is a position's expected profit divided by its investment (or *expected* investment if the investment varies with stock price, as in a naked option position or a futures position). The crucial component, though, is expected profit.

Expected profit is computed by calculating the profitability of a position at a certain stock price times the *probability* of the stock *being* at that price, and summing that multiple over all possible stock prices. When the concept was first introduced, the "probability of the stock being at the price" was given as what we now know is the "endpoint" probability. In reality, a much better measure of the expected profit of a position can be obtained by using one of the more advanced probability estimation models presented above.

In generalized expected return studies done using the fat tails Monte Carlo simulation, certain general conclusions can be drawn about some strategies.

- A bull spread is an inferior strategy when the options are fairly priced, no matter which distribution is assumed. This more or less agrees with observations that have been made previously regarding the disappointments that traders often encounter when using vertical spreads.
- While covered writing might seem superior to stock ownership under the lognormal distribution, the two are about equal under a fat tail distribution.
- Most startling, though, is the fact that option buying strategies fare much, much better under a fat tail distribution than a lognormal one. This most clearly demonstrates the "power" of the fat tail distribution: A limited-risk investment with unlimited profit potential can be expected to perform very well if the fat tails are allowed for.

Using the lognormal distribution more or less represents the conventional wisdom regarding option strategies—the one that many brokers promote: "Don't buy options, don't mess with spreads, either buy stocks or do covered call writes." The fat tail distribution column stands much of that advice on its head. In real life (as demonstrated by the fat tail distribution), strategies with limited profit potential and unlimited or large risk potential are inferior strategies.

One should be aware that the phrase "expected return" is used in many quasisophisticated option analyses (and even in analyses not using options). Many investors accept these "returns" on blind faith, figuring that if they're generated by a computer, they must be correct. In reality, they may not be representative, even for comparisons.

SUMMARY

This chapter has demonstrated that probability analysis is an *inexact* science, because markets behave in ways that are very difficult to describe mathematically. However, probability analysis is also *necessary* for the option strategist; without it he would be in the dark as to the likelihood of profitable outcomes for his strategy. Overall, in a diversified set of positions, the option strategist should use the fat tail distribution in a Monte Carlo simulation to estimate probabilities. However, if that is not available, he can use the normal or lognormal distribution with the proviso that he understands it is not "gospel." He should require very stringent criteria on any strategies that are antivolatility strategies, such as naked option writing of stock options, for there is a greater than normal chance of a large move by the underlying, especially if the underlying is stock.

The sophisticated trader may want to view his probabilities in the light of more than one proposed distribution of prices. Of course, this type of analysis (using several distributions) puts the onus on the investor to choose the distribution that he wants to use in order to analyze his investment. However, such an approach should be extremely illustrative in that he can compare returns from different strategies and have a reasonable expectation as to which ones might perform the best under different market conditions.

CHAPTER 39

Volatility Trading Techniques

The previous three chapters laid the foundation for volatility trading. In this chapter, the actual application of the technique will be described. It should be understood that volatility trading is both an art and a science. It's a science to the extent that one must be rigorous about determining historical volatility or implied volatility, calculating probabilities, and so forth. However, given the vagaries of those measurements that were described in some detail in the previous chapters, volatility trading is also something of an art. Just as two fundamental analysts with the same information regarding earnings, sales projection, and so on might have two different opinions about a stock's fortunes, so also can two volatility traders disagree about the potential for movement in a stock.

However, volatility traders do agree on the approach. *It is based on comparing today's implied volatility with what one expects volatility to do in the future.* As noted previously, one's expectations for volatility might be based on volatility charts, patterns of historical volatility and implied volatility, or something as complicated as a GARCH forecasting model. None of them guarantees success. However, we *do* know that volatility tends to trade in a range in the long run. Therefore, the approach that traders agree upon is this: If implied volatility is "low," buy it. If it's "high," sell it with caution. So simple: Buy low, sell high (not necessarily in that order). The theory behind volatility trading is that it's *easier* to buy low and sell high (or at least to determine what's "low" and "high") when one is speaking about volatility, than it is to do the same thing when one is talking about stock prices.

Most of the time, implied volatility will not be significantly high or low on any particular stock, futures contract, or index. Therefore, the volatility trader will have little interest in most stocks on any given day. This is especially true of the big-cap stocks, the ones whose options are most heavily traded. There are so many traders watching the situation for those stocks that they will rarely let volatility get to the extremes that one would consider "too high" or "too low." Yet, with the large number of optionable stocks, futures, and indices that exist, there are always *some* that are out of line, and that's where the independent volatility trader will concentrate his efforts.

Once a volatility extreme has been uncovered, there are different methods of trading it. Some traders—market-makers and short-term traders—are just looking for very fleeting trades, and expect volatility to fall back into line quickly after an aberrant move. Others prefer more of a position traders' approach: attempting to determine volatility extremes that are so far out of line with accepted norms that it will probably take some time to move back into line. Obviously, the trader's own situation will dictate, to a certain extent, which strategy he pursues. Things such as commission rates, capital requirements, and risk tolerance will determine whether one is more of a short-term trader or a position trader. The techniques to be described in this chapter apply to both methods, although the emphasis will be on position trading.

TWO WAYS VOLATILITY PREDICTIONS CAN BE WRONG

When traders determine the implied volatility of the options on any particular underlying instrument, they may generally be correct in their predictions; that is, implied volatility will actually be a fairly good estimate of forthcoming volatility. However, when they're *wrong*, they can actually be wrong in two ways: either in the outright prediction of volatility or in the *path* of their volatility predictions. Let's discuss both. When they're wrong about the absolute level of volatility, that merely means that implied volatility is either "too low" or "too high." In retrospect, one could only make that assessment, of course, after having seen what actual volatility turned out to be over the life of the option. The second way they could be wrong is by making the implied volatility on *some* of the options on a particular underlying instrument. This is called a *volatility skew* and it is usually an incorrect prediction about the way the underlying will perform during the life of the options.

The rest of this chapter will be divided into two main parts, then. The first part will deal with volatility from the viewpoint of the absolute level of implied volatility being "wrong" (which we'll call "trading the volatility prediction"), and the second part will deal with trading the volatility skew.

TRADING THE VOLATILITY PREDICTION

The volatility trader must have some way of determining when implied volatility is sufficiently out of line that it warrants a trade. Then he must decide what trade to establish. Furthermore, as with any strategy—especially option strategies—follow-up action is important, too. We will not be introducing any new strategies, per se, in this chapter. Those strategies have already been laid out in the previous chapters of this book. However, we will briefly review important points about those strategies and their follow-up actions where it is appropriate.

First, one must try to find situations in which implied volatility is out of line. That is not the end of the analysis, though. After that, one needs to do some probability work and needs to see how the underlying has behaved in the past. Other fine-tuning measures are often useful, too. These will all be described in this chapter.

DETERMINING WHEN VOLATILITY IS OUT OF LINE

There is much disagreement among volatility traders regarding the best method to use for determining if implied volatility is "out of line." Most favor comparing implied with historical volatility. However, it was shown two chapters ago that implied volatility is not necessarily a good predictor of historical volatility. Yet this approach cannot be discarded; however it must be used judiciously. Another approach is to compare today's implied volatility with where it has been in the past. This concept relies heavily on the concept of the *percentile* of implied volatility. Finally, there is the approach of trying to "read" the charts of implied and historical volatility. This is actually something akin to what GARCH tries to do, but on a short-term horizon. So the approaches are:

1. Compare implied volatility to its own past levels (percentile approach).
2. Compare implied volatility to historical volatility.
3. Interpret the chart of volatility.

In addition, we will examine two lesser-used methods: comparing current levels of historical volatility to past measures of historical volatility, and finally, using only a probability calculator and trading the situation that has the best probabilities of success.

THE PERCENTILE APPROACH

In this author's opinion, there is much merit in the percentile approach. When one says that volatility tends to trade in a range, which is the basic premise behind volatility trading, he is generally talking about implied volatility. Thus, it makes sense to know where implied volatility *is* within the range of the past readings of implied volatility. If volatility is low with respect to where it usually trades, then we can say the options are cheap. Conversely, if it's high with respect to those past values, then we can say the options are expensive. These conclusions do not draw on historical volatility.

The *percentile* of implied volatility is generally used to describe just where the current implied volatility reading lies with respect to its past values. The "implied volatility" reading that is being used in this case is the *composite* reading—the one that takes into account all the options on an underlying instrument, weighting them by their distance in- or out-of-the-money (at-the-money gets more weight) and also weighting them by their trading volume. This technique has been referred to many times and was first described in Chapter 28 on mathematical applications. That composite implied volatility reading can be stored in a database for each underlying instrument every day. Such databases are available for purchase from firms that specialize in option data. Also, snapshots of such data are available to members of www.optionstrategist.com.

In general, most underlying instruments would have a composite implied volatility reading somewhere near the 50th percentile on any given day. However, it is not uncommon to see *some* underlyings with percentile readings near zero or 100% on a given day. These are the ones that would interest a volatility trader. Those with readings in the 10th percentile or less, say, would be considered "cheap"; those in the 90th percentile or higher would be considered expensive.

In reality, the percentile of implied volatility is going to be affected by what the broad market is doing. For example, during a severe market slide, implied volatilities will increase across the board. Then, one may find a large number of stocks whose options are in the 90th percentile or higher. Conversely, there have been other times when overall implied volatility has declined substantially: 1993, for example, and the summer of 2001, for another. At those times, we often find a great number of stocks whose options reside in the 10th percentile of implied volatility or lower. The point is that the distribution of percentile readings is a dynamic thing, not something static like a lognormal distribution. Yes, perhaps over a long period of time and taking into account a great number of cases, we might find that the percentiles of implied volatility are normally distributed, but not on any given day.

The trader has some discretion over this percentile calculation. Foremost, he must decide how many days of past history he wants to use in determining the percentiles. There are about 255 trading days in a year. So, if he wanted a two-year history, he would record the percentile of today's composite implied volatility with respect to the 510 daily readings over the past two years. This author typically uses 600 days of implied volatility history for the purpose of determining percentiles, but a case could be made for other lengths of time. The purpose is to use enough implied volatility history to give one a good perspective. Then, a reading of the 10th percentile or the 90th percentile will truly be significant and would therefore be a good starting point in determining whether the options are cheap or expensive.

In addition to the actual percentile, the trader should also be aware of the *width* of the implied volatility distribution. This was discussed in an earlier chapter, but essentially the concept is this: If the first percentile is an implied volatility of 40% and the 100th percentile is an implied volatility of 45%, then that entire range is so narrow as to be meaningless in terms of whether one could classify the options as cheap or expensive.

The advantage of buying options in a low percentile of implied volatility is to give oneself two ways to make money: one, via movement in the underlying (if a straddle were owned, for example), and two, by an increase in implied volatility. That is, if the options were to return to the 50th percentile of implied volatility, the volatility trader who has bought "cheap" options should expect to make money from that movement as well. That can only happen if the 50th percentile and the 10th percentile are sufficiently far apart to allow for an increase in the price of the option to be meaningful. Perhaps a good rule of thumb is this: *If the option rises from the current (low) percentile reading to the 50th percentile in a month, will the increase in implied volatility be equal to or greater than the time decay over that period?* Alternatively stated, with all other things being equal, will the option be trading at the same or a greater price in a month, if implied volatility rises to the 50th percentile at the end of that time? If so, then the width of the range of implied volatilities is great enough to produce the desired results.

The attractiveness to this method for determining if implied volatility is out of line is that the trader is "forced" to buy options that are cheap (or to sell options that are expensive), on a relative basis. Even though historical volatility has not been taken into consideration, it will be later on when the probability calculators are brought to bear. There is no guarantee, of course, that implied volatility will move toward the 50th percentile while the position is in place, but if it does, that will certainly be an aid to the position.

In effect this method is measuring what the option trading public is "thinking" about volatility and comparing it with what they've thought in the past. Since the public is wrong (about prices as well as volatility) at major turning points, it is valid to want to be long volatility when "everyone else" has pushed it down to depressed levels. The converse may not necessarily be true: that we would want to be short volatility when everyone else has pushed it up to extremely high levels. The caveat in that case is that someone may have inside information that justifies expensive options. This is another reason why selling volatility can be difficult: You may be dealing with far less information than those who are actually *making* the implied volatility high.

COMPARING IMPLIED AND HISTORICAL VOLATILITY

The most common way that traders determine which options are cheap or expensive is by comparing the current composite implied volatility with various historical volatility measures. However, just because this is the conventional wisdom does not necessarily mean that this method is the preferred one for determining which options are best for volatility trades. In this author's opinion, it is inferior to the percentile method (comparing implied to past measures of implied), but it does have its merits. The theory behind using this method is that it is a virtual certainty that implied and historical volatility will *eventually* converge with each other. So, if one establishes volatility trading positions when they are far apart, there is supposedly an advantage there.

However, this argument has plenty of holes in it. First of all, there is no guarantee that the two will converge in a timely manner, for example, before the options in the trader's position can become profitable. Historical and implied volatility often remain fairly far apart for weeks at a time.

Second, even if the convergence does occur, it doesn't necessarily mean one will make money. As an example, consider the case in which implied volatility is 40% and historical volatility is 60%. That's quite a difference, so you'd want to buy volatility. Furthermore, suppose the two do converge. Does that mean you'll make money? No, it does not. What if they converge and meet at 40%? Or, worse yet, at 30%? You'd most certainly lose in those cases as the stock slowed down while your option lost time value.

Another problem with this method is that implied volatility is not necessarily low when it is bought, nor high when it is sold. Consider the example just cited. We merely knew that implied volatility was 40% and that historical volatility was 60%. We had no perspective on whether 40% was high, medium, or low. Thus, it is also necessary to see what the *percentile of implied volatility* is. If it turns out that 40% is a relatively high reading for implied volatility, as determined by looking at where implied volatility has been over the past couple of years, then we would probably *not* want to buy volatility in this situation, even though implied and historical volatility have a large discrepancy between them.

Many market-makers and floor traders use this approach. However, they are often looking for an option that is briefly mispriced, figuring that volatilities will quickly revert back to where they were. But for a position trader, the problems cited above can be troublesome.

Having said that, if one looks to implement this method of trying to determine when options are out of line, something along the following lines should be implemented. One should ensure that implied volatility is significantly different from *all* of the pertinent historical volatilities. For example, one might require that implied volatility is less than 80% of each of the 10-, 20-, 50-, and 100-day historical volatility calculations. In addition, the current *percentile* of implied volatility should be noted so that one has some relative basis for determining if *all* of the volatilities, historical and implied, are very high or very low. One would *not* want to buy options if they were all in a very high percentile, nor sell them if they were all in a very low percentile.

Often, a volatility chart showing both the implied and certain historical volatilities will be a useful aid in making these decisions. One can not only quickly tell if the options are in a high or low percentile, but he may also be able to see what happened at similar times in the past when implied and historical volatility deviated substantially.

Finally, one needs some measure to ensure that, if convergence between implied and historical volatility *does* occur, he will be able to make money. So, for example, if one is buying a straddle, he might require that if implied rises to meet historical (say, the *lowest* of the historicals) in a month, he will actually make money. One could use a different time frame, but be careful not to make it something unreasonable. For example, if implied volatility is currently 40% and historical is 60%, it is highly unlikely that implied would rise to 60% in a day or two. Using this criterion also ensures that the *absolute* difference between implied and historical volatility is wide enough to allow for profits to be made. That is, if implied is 10% and historical is 13%, that's a difference of 30% in the two—ostensibly a "wide" divergence between implied and historical. However, if implied rises to meet historical, it will mean only an absolute increase of 3 percentage points in implied volatility—probably not enough to produce a profit, after costs, if any length of time passes.

If all of these criteria are satisfied, then one has successfully found "mispriced" options using the implied versus historical method, and he can proceed to the next step in the volatility analysis: using the probability calculator.

READING THE VOLATILITY CHART

Another technique that traders use in order to determine if options are mispriced is to actually try to analyze the *chart* of volatility—typically implied volatility, but it could be historical. This might seem to be a subjective approach, except that it is really not much different from the GARCH approach, which is considered to be highly advanced. When one views the volatility chart, he is not looking for chart patterns like technical analysts might do with stock charts: support, resistance, head-and-shoulders, flags, pennants, and so on. Rather, he is merely looking for the *trend* of volatility to change.

This is a valid approach in the use of many indicators, particularly sentiment indicators, that can go to extreme levels. By waiting for the *trend* to change, the user is not subjecting himself to buying into the midst of a downtrend in volatility, nor selling into the midst of a steep uptrend in volatility.

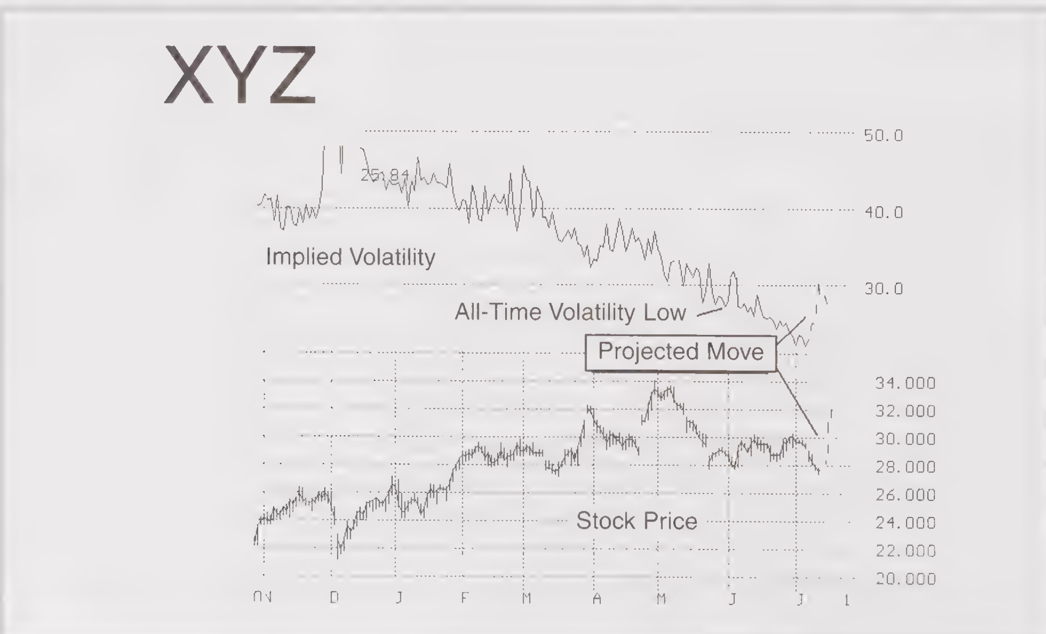
Example: Suppose a volatility trader has determined that the current level of implied volatility for XYZ stock is in the 1st percentile of all past readings. Thus, the options are as cheap as they've ever been. Perhaps, though, the overall market is experiencing a very dull period, or XYZ itself has been in a prolonged, tight trading range—either of which might cause implied volatility to decline steadily and substantially. Having found these cheap options, he wants to buy volatility. However, he has no guarantee that implied volatility won't continue to decline, even though it is already as cheap as it's ever been.

If he follows the technique of waiting for a reversal in the *trend* of implied volatility, then he would keep an eye on XYZ's implied volatility daily until it had at least a modest increase, something to indicate that option buyers have become more interested in XYZ's options. The chart in Figure 39-1 shows how this situation might look.

There are a number of items marked on the chart, so it will be described in detail. There are two graphs in Figure 39-1: The top line is the implied volatility graph, while on the bottom is the stock *price* chart. The implied volatility chart shows that, near the first of June, it made new all-time lows near 28% (i.e., it was in the 0th percentile of implied volatility). Hence, one might have bought volatility at that point. However, it is obvious that implied volatility was in a steep downtrend at that time, so the volatility trader who reads the charts might have decided to wait for a pop in volatility before buying. This turned out to be a judicious decision, because the stock went nowhere for nearly another month and a half, all the while volatility was dropping. At the right of the chart, implied volatility has dropped to nearly 20%.

The solid lines on the two graphs indicate the data that is known about the implied volatility and price history of XYZ. The dotted lines indicate a scenario that might unfold.

FIGURE 39-1.
Chart of the trend of implied volatility.



If implied volatility were to jump (and the stock price might jump, too), then one might think that the trend of implied volatility was no longer down, and he would *then* buy volatility.

The reason that this approach has merit is that one never knows how low volatility can go, and more important, how *high* it can get. It was mentioned that the same sort of approach works well for other sentiment indicators, the put–call ratio, in particular. During the bull market of the 1990s, the equity-only put–call ratio generally ranged between about 30 and 55. Thus, some traders became accustomed to buying the market when the put–call ratio reached numbers exceeding 50 (high put–call ratio numbers are bullish predictors for the market in general). However, when the bull market ended, or at least faltered, the put–call ratios zoomed to heights near 70 or 75. Thus, those using a static approach (that is, "Buy at 50 or higher") were buried as they bought too early and had to suffer while the put–call ratios went to new all-time highs. A trend reversal approach would have saved them. It is a more dynamic procedure, and thus one would have let the put–call ratio continue to rise until it peaked. *Then* the market could have been bought.

This is exactly what reading the volatility chart is about. Rather than relying on past data to indicate where the absolute maxima and minima of movements might occur, one rather notes that the volatility data is at extreme levels (1st percentile or 100th percentile) and then watches it until it reverses direction. This is especially useful for options sellers, because it avoids stepping into the vortex of massive option buying, where the buyers perhaps have inside information about some forthcoming corporate event such as a takeover. True, the options might *be* very expensive (100th percentile), but there is a reason they are, and those with the inside information know the reason, whereas the typical volatility trader might not. However, if the volatility trader merely waits for a downturn in implied volatility readings before selling these options, he will most likely avoid the majority of trouble because the options will probably *not* lose implied volatility until news comes out or until the buyers give up (perhaps figuring that the takeover rumor has died).

Volatility *buyers* don't face the same problems with early entry that volatility sellers do, but still it makes sense to wait for the trend of volatility to increase (as in Figure 39-1) before trying to guess the bottom in volatility. Just as it is usually foolhardy to buy a stock that is in a severe downtrend, so it may be, too, with buying volatility.

A less useful approach would be to apply the same techniques to historical volatility charts, for such charts say nothing about *option* prices. See the next section for expansion on these thoughts.

COMPARING HISTORICAL VERSUS HISTORICAL

The above paragraphs summarize the three major ways that traders attempt to find options that are out of line. Sometimes, another method is mentioned: comparing current levels of historical volatility with past levels of the same measure, historical volatility. This method will be described, but it is generally an inferior method because such a comparison doesn't tell us anything about the *option* prices. It would do little good, for example, to find that current historical volatility is in a very low percentile of historical volatilities, only to learn later that the options are expensive and that perhaps implied volatility is even *higher* than historical volatility. One would normally *not* want to buy options in that case, so the initial analysis of comparing historical to historical is a wasted effort.

Comparing current levels of historical volatility with past measures of historical volatility is sort of a backward-looking approach, since historical volatility involves strictly the use of *past* stock prices. There is no consideration of implied volatility in this approach. Moreover, this method makes the tacit assumption that a stock's volatility characteristics do not change, that it will revert to some sort of "normal" past price behavior in terms of volatility. In reality, this is not true at all. Nearly every stock can be shown to have considerable changes in its historical volatility patterns over time.

Consider the historical volatilities of one of the wilder stocks of the tech stock boom, Rambus (RMBS). Historical volatilities had ranged between 50% and 110%, from the listing of RMBS stock, through February 2000. At that time, the stock averaged a price of about $20 per share.

Things changed mightily when RMBS stock began to rise at a tremendous rate in February 2000. At that time, the stock blasted to 115, pulled back to 35, made a new high near 135, and then collapsed to a price near 20. Hence, the stock itself had completed a wild round-trip over the two-year period. See Figures 39-2 and 39-3 for the stock chart and the historical volatility chart of RMBS over the time period in question.

As this happened, historical volatility skyrocketed. After February 2000, and well into 2001, historical volatility was well above 120%. Thus it is clear that the behavior patterns of Rambus changed greatly after February 2000. However, if one had been comparing historical volatilities at any time after that, he would have erroneously concluded that RMBS was about to slow down, that the historical volatilities were too high in comparison with where they'd been in the past. If this had led one to sell volatility on RMBS, it could have been a very expensive mistake.

While RMBS may be an extreme example, it is certainly not alone. Many other stocks experienced similar changes in behavior. In this author's opinion, such behavior debunks the usefulness of comparing historical volatility with past measures of historical volatility as a valid way of selecting volatility trades.

What this method may be best used for is to complement the other methods described previously, in order to give the volatility trader some perspective on how volatile he can expect the underlying instrument to be; but it obviously has to be taken only as a general guideline.

FIGURE 39-2.
Historical volatilities of RMBS.

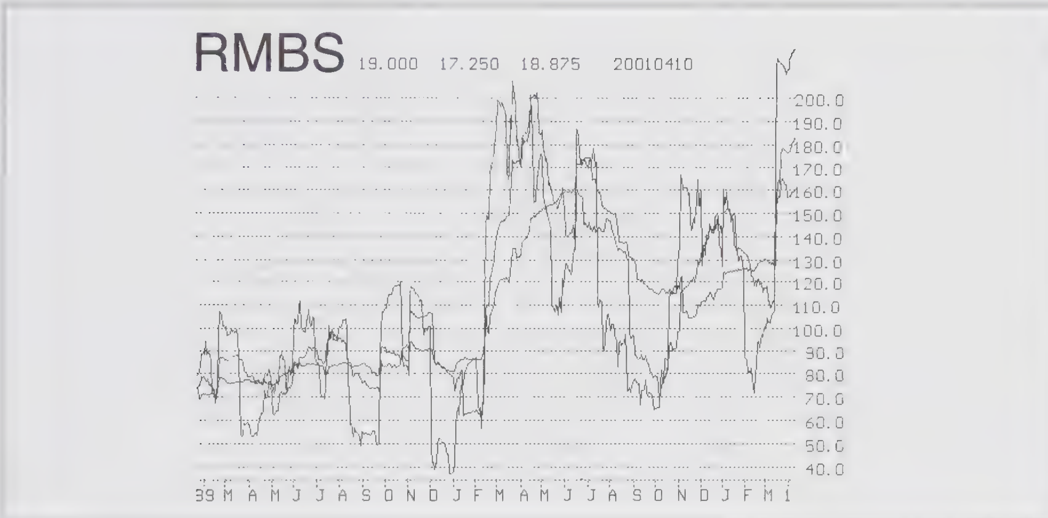
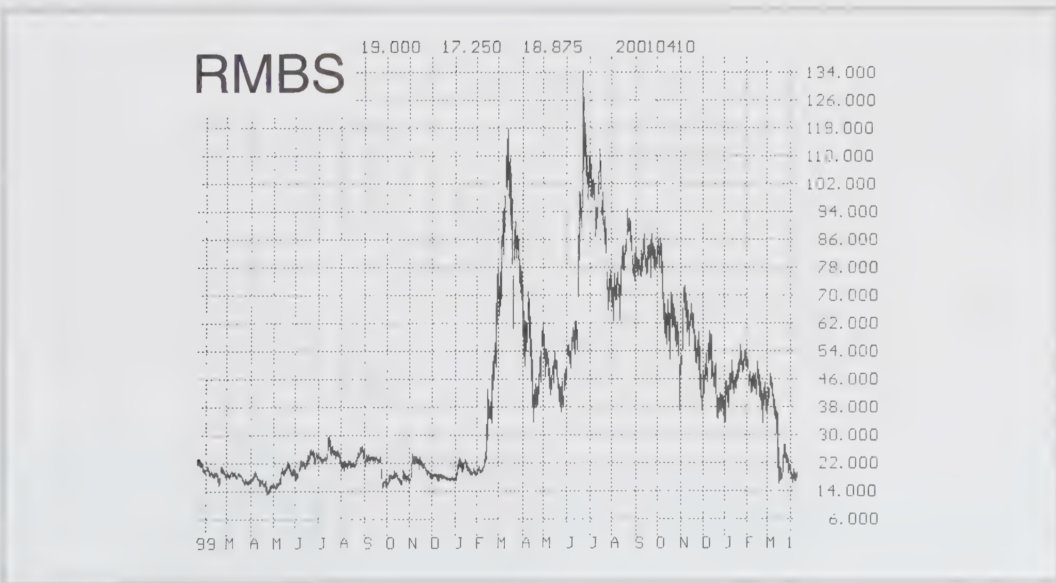


FIGURE 39-3.
Stock chart of RMBS.



CHECK THE FUNDAMENTALS

Once these mispriced options have been found, it is always imperative to check the news to see if there is some fundamental reason behind it. For example, if the options are extremely cheap and one then checks the news stories and finds that the underlying stock has been the beneficiary of an all-cash tender offer, he would *not* buy those options. The stock is not going to go anywhere, and in fact will disappear if the deal goes through as planned.

Similarly, if the options appear to be very expensive, and one checks the news and finds that the underlying has a product up for review before a governmental agency (FDA, for example), then the options should *not* be sold because the stock may be about to undergo a large gap move based on the outcome of FDA hearings. There could be any number of similar corporate events that would make the options very expensive. The seller of volatility should *not* try to intercede when such events or rumors are occurring.

However, if there is no news that would seem to explain why the options are so cheap or so expensive, then the volatility trader can continue on to the rest of his analyses.

SELECTING THE STRATEGY TO USE

In general, when one wants to trade volatility, a simple approach is best, especially if one is *buying* volatility. If there is a volatility *skew* involved, then there may be other strategies that are superior, and they are discussed in the latter part of this chapter. However, when one is interested in the straight trading of volatility because he thinks implied volatility is out of line, then only a few strategies apply.

If volatility is too low, then either a straddle or a strangle should be purchased. One would normally choose a straddle if the underlying instrument is currently trading near an available striking price. However, if the underlying is currently trading *between* two striking prices, then a strangle might be the better choice. In either case, a position trader would want to buy a straddle with several months of life remaining, in order to improve his chances of making a profit. There is no "best" time length to use, so one should use a probability calculator to aid in that decision. The use of probability calculators will be discussed shortly.

Example: XYZ is trading at 39.60 and a volatility trader has determined that he wants to buy volatility. With this information, he should attempt to buy a straddle with a striking of 40 for both the put and the call.

Suppose that the current date is in December, and the available expiration months for XYZ are January, February, April, July, and October, plus LEAPS for January of the next year. Then he would analyze each straddle (January 40, February 40, April 40, etc.) to see which is the best one to buy. It generally seems to work out that the midrange straddles have the best probabilities of success, given the way that option prices are usually structured. Of course, the actual prices of each straddle would be considered when using the probability calculator. In this case, then, the July 40 or October 40 straddle would probably be the best choices from a statistical viewpoint for a position trader.

If XYZ had been trading at a price of 37.50, say, then the trader would probably want to consider buying a strangle: buying a call with a striking price of 40 and a put with a striking price of 35. From the viewpoint of *buying* strangles, it does not make sense to separate the strikes by more than one striking price unit—5 points for stock options, for example. This just makes the position more neutral to begin with.

Speaking of neutrality, one can also use the deltas of the options in question to alter the ratio of puts to calls, making the position initially as neutral as possible. This is the suggested approach, since the volatility buyer does not care whether the stock goes up or down. He is merely interested in stock movement and/or an increase in implied volatility.

Example: XYZ is again trading at 39.60, and the trader wants a neutral position. He should use the deltas of the options to construct a neutral position. Consider the October 40 straddle, for example. Assume the volatility used for the probability calculations is 40%. Under those conditions (and the ones assumed in the previous example), the October 40 call has a delta of 0.60 and the October 40 put has a delta of –0.40. Thus a ratio of buying 2 calls and 3 puts is a neutral ratio. If the call is selling for 6 and the put is selling for 5, then the break-even points for a 2-by-3 position would be 53.5 on the upside and 31 on the downside. This information is summarized as follows:

Delta of October 40 call:	+0.60
Delta of October 40 put:	–0.40
Delta-neutral ratio: buy 2 calls and 3 puts	
Price of October 40 call:	6.00
Price of October 40 put:	5.00
Net cost of 2-by-3 position: 27 points	
Break-even points:	Upside = 40 + 27/2 = 53.50
	Downside = 40 – 27/3 = 31.00

TABLE 39-1.

	January	February	April	July	October	January LEAP
Call price	1.25	2.25	3.50	5.00	6.00	7.15
Put price	1.50	2.35	3.35	4.35	5.00	5.55
Call delta	0.48	0.52	0.55	0.58	0.60	0.62
Put delta	–0.52	–0.48	–0.45	–0.42	–0.40	–0.38
Neutral	~1-to-1	~1-to-1	~1-to-1	~2-to-3	~2-to-3	~2-to-3
Debit	2.75	4.60	6.85	23.05	27.00	30.95
Upside break-even	42.75	44.60	46.85	51.57	53.50	55.47
Downside break-even	37.25	35.40	33.15	32.30	31.00	29.68

So, the probability calculations would endeavor to determine what the chances are of the stock *ever* trading at either 53.50 or 31.00 at any time prior to expiration. In fact, since there are straddles available in several expiration months, the strategist would want to analyze each of them in a similar fashion. Table 39-1 shows how his choices might look. If one were considering buying a *strangle*, similar calculations could be made using the deltas of the put and the call, where the call strike is higher than the put strike.

Another simple strategy that can be used when volatility is low is the calendar spread, because it has a positive vega. That is, it can be expected to expand if implied volatility increases. For most traders, though, the limited profit nature of the calendar spread is too much of a burden, either psychologically or in terms of commissions, and so this strategy is only modestly used by volatility traders. Some traders will use the calendar spread if they don't see immediate prospects for an increase in implied volatility. They perhaps buy a call calendar slightly out-of-the-money and also buy a put calendar with slightly out-of-the-money puts. Then, if not much happens over the short term, the options that were sold expire worthless, and the remaining long straddle or strangle is even more attractive than ever. Of course, this strategy has its drawback in that a quick move by the underlying may result in a loss, something that would *not* have happened had a simple straddle or strangle been purchased.

SELLING VOLATILITY

If one were *selling* volatility (i.e., volatility is too high), his choices are more complex. Virtually anyone who has ever sold volatility has had a bad experience or two with either exploding stock prices or exploding volatility. Some of the concerns regarding the sale of volatility will be discussed at length later in this chapter. For now, the simpler strategies will be considered, in keeping with the discussion involving the creation of a volatility trading position.

Simplistically, a volatility seller would generally have a choice between one of two strategies (although there is a more complicated strategy that can be introduced as well). The simplest strategy is just to sell both an out-of-the-money put and an out-of-the-money call. The striking prices chosen should be far enough away from the current underlying price so that the probabilities of the position getting in trouble (i.e., the probabilities that the underlying actually trades at the striking prices of the naked options during the life of the position) are quite small. Just as the option buyer above outlined several expiration months, then computed the break-even prices, so should a volatility *seller.* Generally he will probably want to sell short-term options, but all expiration months should be considered, at least initially. Also, he may want to try different strike prices in order to get a balance between a low probability of the stock reaching the striking price of the naked options and taking in enough premium to make the trade worthwhile. To this author, the sale of naked options at small fractional prices does not appear attractive.

Of course, merely selling such a put and a call means the options are naked, and that strategy is not suitable for all traders. The next best choice then, I suppose, is a credit spread. The problem with a credit spread is that one is both *selling* expensive options and also *buying* expensive options as protection. The ramifications of volatility changes on the credit spread strategy were detailed two chapters previously, so they won't be recounted here, except to say that if volatility decreases, the profits to be realized by a credit spreader are quite small (perhaps not even enough to overcome the commission expense of removing the position), whereas a naked option seller would benefit to a greater and more obvious extent.

The choice between naked writing and credit spreading should be made based largely on the philosophy and psychological makeup of the trader himself. If one feels uncomfortable with naked options, or if he doesn't have the ability to watch the market pretty much all the time (or have someone watch it for him), or if he doesn't have the financial wherewithal to margin the positions and carry them until the stock hits the break-even point, then naked writing is *not* for that trader.

Another factor that might affect the choice of strategy for the option seller is what type of underlying instrument is being considered. Index options are by far the best choices for naked option selling. Futures are next, and stocks are last. This is because of the ways those various instruments behave; stocks have by far the greatest capability of making huge gap moves that are the bane of naked option selling. So, if one has found expensive stock or futures options, that might lend more credence to the credit spread strategy.

There is one other strategy that can be employed, upon occasion, when options are expensive. It is called the volatility backspread, but its discussion will be deferred until later in the chapter.

USING A PROBABILITY CALCULATOR

No matter which method is used to find options that are out of line, and no matter which strategy is preferred by the trader, it is still necessary to use a probability calculator to get a meaningful idea of whether or not the underlying has the ability to make the move to profitability (or *not* make the move into loss territory, if you're selling options). This is where historical volatility plays a big part, for it is the input into the probability calculator. In fact, no probability calculator will give reasonable predictions without a good estimate of volatility. Please refer to the previous chapter for a more in-depth discussion of probability calculators and stock price distributions.

The use of probability analysis also mitigates some of the problems inherent in the method of selection that compares implied and historical volatilities. If the probabilities are good for success, then we might not care so much whether the options are currently in a low percentile of implied volatility or not (although we still would not want to buy volatility when the options were in a high percentile of implied volatility and we would not want to sell options that are in a low percentile).

In using the probability calculator, one first selects a strategy (straddle buying, for example, if options are cheap) and then calculates the break-even points as demonstrated in the previous section. Then the probability calculator is used to determine what the chances are of the underlying instrument *ever* trading at one or the other of those break-even prices at any time during the life of the option position. It was shown in the previous chapter that a Monte Carlo simulation using the fat tail distribution is best used for this process.

An attractive volatility buying situation should have probabilities in excess of 80% of the underlying ever exceeding the break-even point, while an attractive volatility selling situation should have probabilities of less than 25% of ever trading at prices that would cause losses. The volatility seller can, of course, heavily influence those probabilities by choosing options that are well out-of-the-money. As noted above, the volatility seller should, in fact, calculate the probabilities on several different striking prices, striving to find a balance between high probability of success and the ability to take in enough premium to make the risk worthwhile.

Example: The OEX Index is trading at 650. Suppose that one has determined that volatilities are too high and wants to analyze the sale of some naked options. Furthermore, suppose that the choices have been narrowed down to selling the September options, which expire in about five weeks. The main choices under consideration are those in Table 39-2. The option prices in this example, being index options, reflect a volatility skew (to be discussed later) to make the example realistic.

The two right-hand columns should be rejected because the probabilities of the

TABLE 39-2.

Naked sale:	September 800 call September 500 put	September 750 call September 550 put	September 730 call September 570 put	September 700 call September 600 put
Call price	0.20	1.50	3.50	8.80
Put price	0.40	2.00	3.70	8.50
Probability of call strike	4%	17%	30%	44%
Probability of put strike	1%	11%	20%	40%

stock hitting one or the other of the striking prices prior to expiration are too high—well in excess of the 25% guideline mentioned earlier. That leaves the September 500-800 strangle or the September 550-750 strangle to consider. The probabilities are best for the farthest out-of-the-money options (September 500-800 strangle), but the options are selling at such small prices that they will not provide much of a return even if they expire worthless. Remember that one is required to establish the position with margin of at least 10% of the index price for naked index options, which would be $6,500 in this case. In fact, it has been recommended that one margin the position at the striking price itself (15% of 800, or $12,000 in this case). So, taking in only $60, less commissions, for the sale of the September 500-800 strangle doesn't seem to provide enough of a reward. Thus, the best choice seems to be the September 550-750 strangle. One would be making about $320 after commissions if the options expired worthless, and the recommended margin would be 15% of 750 (the higher strike), or $11,250—a return of about 2.8% for one month. One cannot annualize these returns, for he has no idea if the same option pricing structure will exist in five weeks, when these options expire.

Other probabilities can be calculated as well. For example, suppose one has decided to buy a straddle. He might want to know what the odds are not only of breaking even, but also of making at least a certain percentage return—say 20%. One could also calculate the probability of the stock moving 20% *past* the break-even points. That distance—20%—is a reasonable figure to use because one would most likely be taking some partial profits or adjusting his position if the stock did indeed move that far.

USING STOCK PRICE HISTORY

All of the work done so far—determining which options are expensive, selecting a strategy, and calculating the probabilities of success—has been somewhat theoretical in that we haven't done any "back testing" with regard to the volatility of the underlying instruments. At this point, one should look at past prices to see if the stock has been able to make large moves (whether or not such a move is desired).

Example: A trader is considering the purchase of the XYZ October 40 straddle for 11 points, with the stock at 39.60. The options are cheap and the probabilities of success appear to be good, according to the probability calculator. The question that now needs to be asked and answered is this: "In the past, has this stock been able to move 11 points in 10 months (the time remaining in the straddle's life)?" Or, more importantly, since 11 divided by 39.60 is about 28%, "Has this stock been able to make moves of 28% over 10 months, in the past?" The answers to these questions can be readily obtained if stock price history data is available. One could even look at a chart of the stock and attempt to answer the questions himself without the aid of a computer, but computer analysis of the price history is more rigorous and is therefore encouraged.

The answers can be expressed in the form of probabilities, much as the results of the probability calculator are.

Suppose one determines that the stock has been able to move 11 points in 10 months 77% of the time in the past. That's okay, but not great. However, when one looks at the price chart of XYZ, he sees that it traded at much lower prices—near $10 a share—for a long time before rising to its current levels. It would be very hard to expect a $10 stock to move 11 points in 10 months. That's why the second figure, the one involving the 28% move, is the more significant one. In this case, one might find that XYZ has been able to move 28% in 10 months over 90% of the time in the past. *Now* one has what appears to be a decent-looking straddle buy.

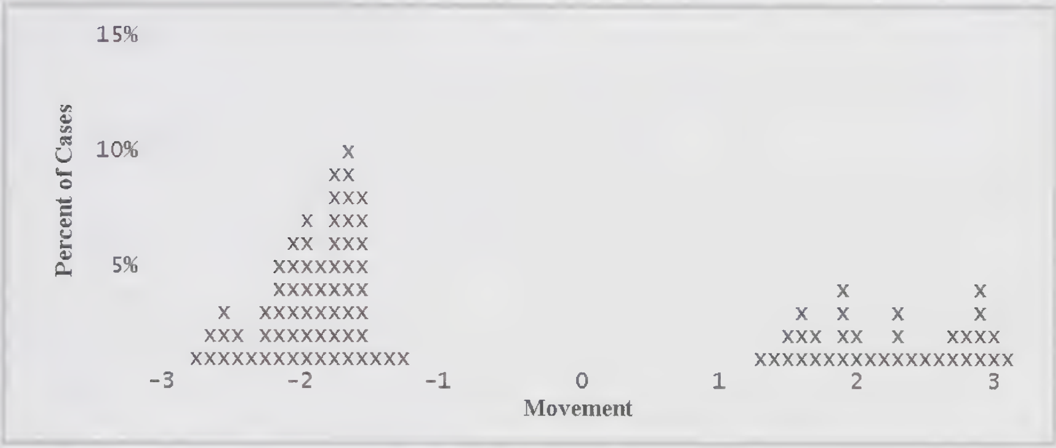
This analysis of past prices can be done in a more sophisticated manner. Rather than just asking whether or not the stock has moved the required distance in the past, one might want to see just how the stock's movements "look." That is, there are a couple of scenarios under which the past movements might look attractive, but upon closer examination, one would not be so sanguine.

For example, what if XYZ had repeatedly moved 28%, but never much more in most of the 10-month periods that comprise its stock history? Then, one would be less inclined to want to own this straddle.

Another scenario of past movements might be that XYZ had made moves that one could not reasonably expect to be repeated. Perhaps there was a huge gap down on an earnings shortfall, or if it was an Internet stock around the turn of the millennium, it had a huge move upward, followed by a huge move downward. That would be another non-repeating type of move, because absent the Internet mania, the stock might have been a rather range-bound item both prior to and after the one huge, round-trip move.

These problems could be addressed by merely looking at the chart, but the naked

FIGURE 39-4.
Histogram of XYZ movements. (Testing 28% move in ten months.)

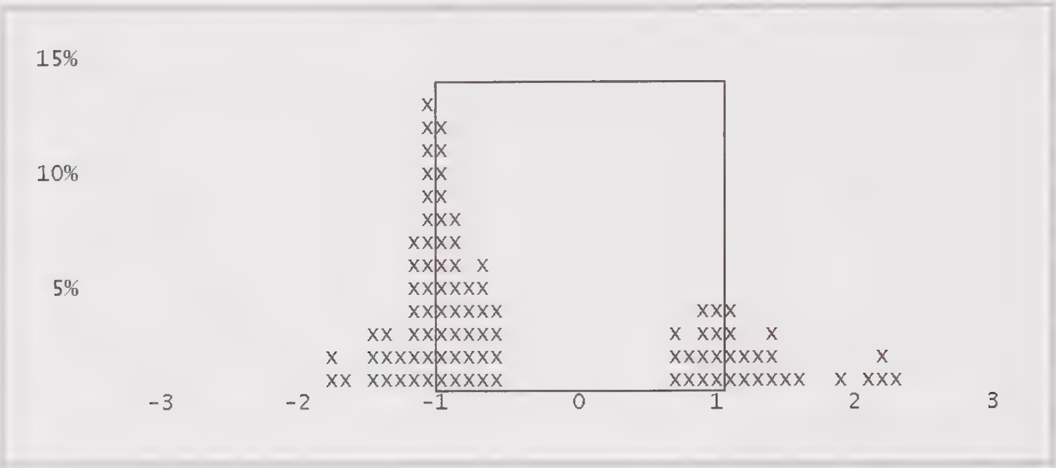


eye can be deceiving in many cases. Rather, a more rigorous approach would be to construct a histogram of these past stock movements and analyze the histogram.

Figure 39-4 shows such a histogram. The x-axis shows the magnitude of each 10-month move that is in the database of XYZ stock prices. A move to "1" would mean that it moved the 28% and no farther over the 10-month period. A move to "–2" indicates that it fell 56% (twice the required distance) during the 10-month period. The y-axis (left-hand scale) shows the percentage of times that the move occurred. The sample histogram shown in Figure 39-4 is actually a very favorable one. Notice that the stock was always able to move at least 28%. Furthermore, it moved two or three times that far with great frequency. Finally, there is a continuity to the points on the histogram: There are some y-axis data points at almost all points on the x-axis (between the minimum and maximum x-axis points). That is good, because it shows that there has not been a clustering of movements by XYZ that might have dominated past activity.

As for what is *not* a "good" histogram, we would not be so enamored of a histogram that showed a huge cluster of points near and between the "–1" and "1" points on the x-axis. We want the stock to have shown an ability to move *farther* than just the break-even distance, if possible. As an example, see Figure 39-5, which shows a stock whose movements rarely exceed the "–1" or "+1" points, and even when they do, they don't exceed it by much. Most of these would be losing trades because, even though the stock might have moved the required percentage, that was its *maximum* move during the 10-month period, and there is no way that a trader would know to take profits exactly at that time. The straddles described by the histogram in Figure 39-5 should not be bought, regardless of what the previous analyses might have shown.

FIGURE 39-5.
Example of poor movement.



Nor would it be desirable for the histogram to show a large number of movements *above* the "+3" level on the histogram, with virtually nothing below that. Such a histogram would most likely be reflective of the spiky, Internet-type stock activity that was referred to earlier as being unreasonable to expect that it might repeat itself. In a general sense, one doesn't want to see too many open spaces on the histogram's x-axis; continuity is desired.

If the histogram is a favorable one, then the volatility analysis is complete. One would have found mispriced options, with a good theoretical probability of profit, whose past stock movements verify that such movements are feasible in the future.

ANOTHER APPROACH?

After having considered the descriptions of all of these analyses, one other approach comes to mind: *Use the past movements exclusively and ignore the other analyses altogether.* This sounds somewhat radical, but it is certainly a valid approach. It's more like giving some rigor to the person who "knows" IBM can move 18 points and who therefore wants to buy the straddle. If the histogram (study of past movements) tells us that IBM does, indeed, have a good chance of moving 18 points, what do we really care about the relationship of implied and historical volatility, or about the current percentiles of either type of volatility, or what a theoretical probability calculator might say? In some sense, this is like comparing implied volatility (the price of the straddle) with historical volatility (the history of stock price movements) in a strictly practical sense, not using statistics.

In reality, one would have to be mindful of not buying overly expensive options (or selling overly cheap ones), because implied volatility cannot be ignored. However, the price of the straddle itself, which is what determines the x-axis on the histogram, does reflect option prices, and therefore implied volatility, in a nontechnical sense. This author suspects that a list of volatility trading candidates generated only by using past movements would be a rather long list. Therefore, as a practical matter, it may not be useful.

MORE THOUGHTS ON SELLING VOLATILITY

Earlier, it was promised that another, more complex volatility selling strategy would be discussed. An option strategist is often faced with a difficult choice when it comes to selling (overpriced) options in a neutral manner—in other words, "selling volatility." Many traders don't like to sell naked options, especially naked *equity* options, yet many forms of spreads designed to limit risk seem to force the strategist into a directional (bullish or bearish) strategy that he doesn't really want. This section addresses the more daunting prospect of trying to sell volatility *with protection* in the equity and futures option markets.

The quandary in trying to sell volatility is in trying to find a neutral strategy that allows one to benefit from the sale of expensive options without paying too much for a hedge—the offsetting purchase of equally expensive options. The simple strategy that most traders first attempt is the credit spread. Theoretically, if implied volatility were to fall during the time the credit spread position is in place, a profit might be realized. However, after commissions on four different options in and possibly out (assuming one sold both out-of-the-money put and call spreads), there probably wouldn't be any real profit left if the position were closed out early. In sum, there is nothing really wrong with the credit spread strategy, but it just doesn't seem like anything to get too excited about. What other strategy can be used that has limited risk and would benefit from a decline in implied volatility? The highest-priced options are the longer-term ones. If implied volatility is high, then if one can sell options such as these and hedge them, that might be a good strategy.

The simplest strategy that has the desired traits is selling a calendar spread—that is, sell a longer-term option and hedge it by buying a short-term option at the same strike. True, both are expensive (and the near-term option might even have a slightly higher implied volatility than the longer-term one). But the longer-term one trades with a far greater absolute price, so if both become cheaper, the longer-term one can decline quite a bit farther in points than the near-term one. That is, the *vega* of the longer-term option is greater than the vega of the shorter-term one. When one sells a calendar spread, it is called a *reverse calendar spread*. The strategy was described in the chapter on reverse spreads. The reader might want to review that chapter, not only for the description of the strategy, but also for the description of the margin problems inherent in reverse spreads on stocks and indices.

One of the problems that most traders have with the reverse calendar spread is that it doesn't produce very large profits. The spread can theoretically shrink to zero after it is sold, but in reality it will not do so, for the longer-term option will retain *some* amount of time value premium even if it is very deeply in- or out-of-the-money. Hence the spread will never really shrink to zero.

Yet, there is another approach that can often provide larger profit potential and still retain the potential to make money if implied volatility decreases. In some sense it is a modification of the reverse calendar spread strategy that can create a potentially even more desirable position. The strategy, known as a *volatility backspread*, involves selling a long-term at-the-money option (just as in the reverse calendar spread) and then buying a greater number of nearer term out-of-the-money options. The position is generally constructed to be delta-neutral and it has a negative vega, meaning that it will profit if implied volatility decreases.

Example: XYZ is trading at 115 in early June. Its options are very expensive. A trader would like to construct a volatility backspread using the following two options:

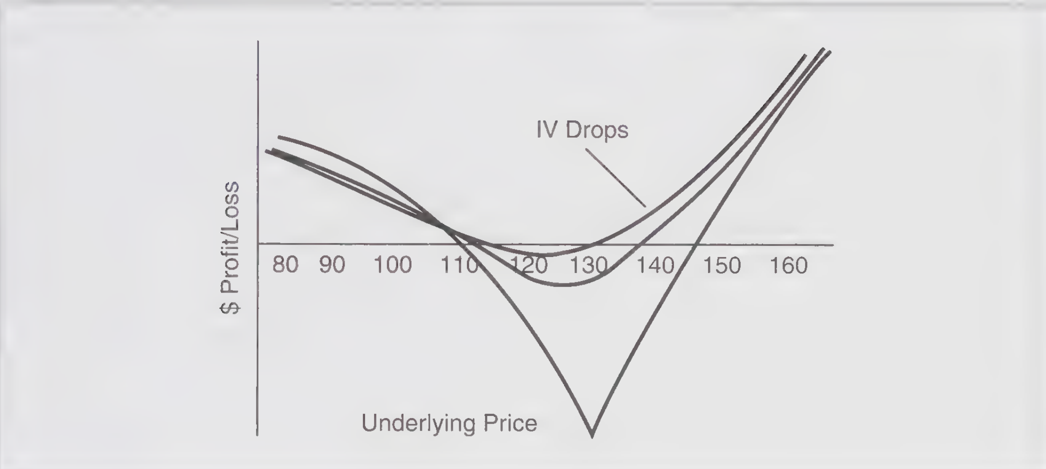
Call Option	Price	Delta	Vega
July 130 call:	2.50	0.26	0.10
October 120 call:	13	0.53	0.27

A delta-neutral position would be to buy 2 of the July 130 calls and sell one of the October 120 calls. This would bring in a credit of 8 points. Also, it would have a small negative position vega, since two times the vega of the July calls minus one times the vega of the October call is −0.07. That is, for each one percentage point drop in implied volatility of XYZ options in general, this position would make $7—not a large amount, but it *is* a small position.

The profitability of the position is shown in Figure 39-6. This strategy has limited risk because it does *not* involve naked options. In fact, if XYZ were to rally by a good distance, one could make large profits because of the extra long call. Meanwhile, on the downside, if XYZ falls heavily, all the options would lose most of their value and one would have a profit approaching the amount of the initial credit received. Furthermore, a decrease in implied volatility produces a small profit as well, although time decay may not be in the trader's favor, depending on exactly which short-term options were bought. The biggest risk is that XYZ is exactly at 130 at July expiration, so any strategist employing this strategy should plan to close it out in advance of the near-term expiration. It should not be allowed to deteriorate to the point of maximum loss.

Modifications to the strategy can be considered. One is to sell even longer-term

FIGURE 39-6.
Volatility backspread neutral position.



options and of course hedge them with the purchase of the near-term options. The longer-term the option is, the bigger its vega will be, so a decrease in implied volatility will cause the heftier-priced long-term option to decline more in price. This modification is somewhat tempered, though, by the fact that when options get really expensive, there is often a tendency for the near-term options to be skewed. That is, the near-term options will be trading with a much higher implied volatility than will the longer-term options. This is especially true for LEAPS options. For that reason, one should make sure that he is not entering into a situation in which the shorter-term options could lose volatility while the longer-term ones more or less retain the *same* implied volatility, as LEAPS options often do. This concept of differing volatility between near- and long-term options was discussed in more detail in Chapter 36 on the basics of volatility trading. As a sort of general rule, if one finds that the longer-term option has a much *lower* implied volatility than the one you were going to buy, this strategy is *not* recommended. As a corollary, then, *it is unlikely that this strategy will work well with LEAPS options.*

One other thing that you should analyze when looking for this type of trade is whether *it might be better to use the puts than the calls.* For one thing, you can establish a position in which the heavy profitability is on the downside (as opposed to the upside, as in the XYZ example above). Then, of course, having considered that, it might actually behoove one to establish *both* the call spread and the put spread. If you do both, though, you create a "good news, bad news" situation. The good news is that the maximum risk is reduced; for example, if XYZ goes exactly to 130 (the worst point for the call spread), the companion put spread's credit would reduce that risk a little. However, the bad news is that there is a much wider range over which there is *not* profit, since there are two spots where losses are more or less maximized (at the strike price of the long calls and again at the strike price of the long puts).

Margin will be discussed only briefly, since it was addressed in the chapter on reverse spreads. For both index and stock options, this strategy is considered to have naked options—a preposterous assumption, since one can see from the profit graph that the position is fully hedged until the near-term options expire. This raises the capital requirement for nonmember traders. The margin anomaly is *not* a problem with futures options, however. For those options, one need only margin the difference in the strikes, less any credit received, because that is the true risk of the position. In summary, the volatility trader who wants to *sell* volatility in equity and futures options markets needs to be hedged, because gaps are prevalent and potentially very costly. This strategy creates a more neutral, less price-dependent way to benefit if implied volatility decreases, especially when compared with simple credit spreads.

SUMMARY: TRADING THE VOLATILITY PREDICTION

Attempting to establish trades when implied volatility is out of line is a theoretically attractive strategy. The process outlined above consisted of a few steps, employing both statistical and theoretical analysis. In any case, though, probability calculators must "say" that a volatility trade has good probabilities of success. It's merely a matter of what criteria we apply to limit our choices before we run the probability analysis. So, it might be more useful to view volatility trading analysis in this light:

Step 1: Use a selection criterion to limit the myriad of volatility trading choices. Any of these could be used as the first criterion, but not all of them at once:

a. Require implied volatility to be at an extreme percentile.

b. Require historical and implied volatility to have a large discrepancy between them.

c. Interpret the chart of implied volatility to see if it has reversed trend.

Step 2: Use a probability calculator to project whether the strategy can be expected to be a success.

Step 3: Using past price histories, determine whether the underlying has been able to create profitable trades in the past. (For example, if one is considering buying a straddle, ask the question, "Has this stock been able to move far enough, with great enough frequency, to make this straddle purchase profitable?") Use histograms to ensure that the past distribution of stock prices is smooth, so that an aberrant, nonrepeatable move is not overly influencing the results.

Each criterion from Step 1 would produce a different list of viable volatility trading candidates on any given day. If a particular candidate were to appear on more than one of the lists, it might be the best situation of all.

TRADING THE VOLATILITY SKEW

In the early part of this chapter, it was mentioned that there are two ways in which volatility predictions could be "wrong." The first was that implied volatility was out of line. The second is that individual options on the same underlying instrument have significantly different implied volatilities. This is called a volatility skew, and presents trading opportunities in its own right.

DIFFERING IMPLIED VOLATILITIES ON THE SAME UNDERLYING SECURITY

The implied volatility of an option is the volatility that one would have to use as input to the Black–Scholes model in order for the result of the model to be equal to the current market price of the option. Each option will thus have its own implied volatility. Generally, they will be fairly close to each other in value, although not exactly the same. However, in some cases, there will be large enough discrepancies between the individual implied volatilities to warrant the strategist's attention. It is this latter condition of large discrepancies that will be addressed in this section.

Example: XYZ is trading at 45. The following option prices exist, along with their implied volatilities:

Option	Actual Price	Implied Volatility
January 45 call	2.75	41%
January 50 call	1.25	47%
January 55 call	0.63	53%
February 45 call	3.50	38%
February 50 call	4.00	45%

Note that the implied volatilities of the individual options range from a low of 38% to a high of 53%. This is a rather large discrepancy for options on the same underlying security, but it is useful for exemplary purposes.

A neutral strategy could be established by buying options with lower implied volatilities and simultaneously selling ones with higher volatilities, such as buy 10 February 45 calls and sell 20 January 50 calls. Examples of neutral spreads will be expanded upon in the next chapter, when more exact measures for determining how many calls to buy and sell are discussed.

Before jumping into such a position, the strategist should ask himself if there is a valid reason why the different options have such different implied volatilities. As a generalization, it might be fair to say that out-of-the-money options have slightly higher implieds than at-the-money ones, and that longer-term options have lower implieds than short-term ones. But there are many instances in which such is not the case, so one must be careful not to overgeneralize.

Speculators often desire the lowest dollar-cost option available. Thus, in a takeover rumor situation, they would buy the out-of-the-moneys as opposed to the higher-priced at- or in-the-moneys. If the out-of-the-moneys are extremely expensive because of a takeover rumor, then the strategist must be careful, because the neutral strategy concept may lead him into selling naked calls. This is not to say he should avoid the situation altogether; he may be able to structure a position with enough upside room to protect himself, or he may believe the rumors are false.

Returning to the general topic of differing implied volatilities on the same underlying stock, the strategist might ask how he is to determine if the discrepancies between the individual options are significantly large to warrant attention. A mathematical approach is presented at the end of the next chapter in a section on advanced mathematical concepts. Suffice it to say that there is a way that the differences in the various implieds can be reduced to a single number—a sort of "standard deviation of the implieds" that is easy for the strategist to use. A list of these numbers can be constructed, comparing which stocks or futures might be candidates for this type of neutral spreading. On a given day, the list is usually quite short—perhaps 20 stocks and 10 futures contracts will qualify.

The concept of the implied volatilities of various options on the same underlying stock remaining out of line with each other is one that needs more discussion. In the following section, the idea of semipermanent distortion between the volatilities of different striking prices is discussed.

VOLATILITY SKEWING

After the stock market crashed in 1987, index options experienced what has since proven to be a permanent distortion: Out-of-the-money puts have remained more expensive than out-of-the-money calls. Furthermore, out-of-the-money puts are more expensive than at-the-money puts; out-of-the-money calls are cheaper than at-the-money calls. This distorted effect is due to several factors, but it is so deep-seated that it has remained through all kinds of up-and-down markets since then. Other markets, particularly futures markets, have also experienced a long-lasting distortion between the implied volatilities at various strikes.

The proper name given to this phenomenon is *volatility skewing: the long-lasting effect whereby options at different striking prices trade with differing implied volatilities.* It should be noted that the calls and puts at the same strike must trade for the same implied volatility; otherwise, conversion or reversal arbitrage would eliminate the difference. However, there is no true arbitrage between different striking prices. Hence, arbitrage cannot eliminate volatility skewing.

Example: Volatility skewing exists in OEX index options. Assume the average volatility of OEX and its options is 16%. With volatility skewing present, the implied volatilities at the various striking prices might look like this:

OEX: 580

Strike	Implied Volatility of Both Puts and Calls
550	22%
560	19%
570	17%
580	16%
590	15%
600	14%
610	13%

In this form of volatility skewing, the out-of-the-money puts are the most expensive options; the out-of-the-money calls are the cheapest. This pattern of implied volatilities is called a *reverse volatility skew* or, alternatively, a *negative volatility skew.*

The causes of this effect stem from the stock market's penchant to crash occasionally. Investors who want protection buy index puts; they don't sell index futures as much as they used to because of the failure of the portfolio insurance strategy during the 1987 crash. In addition, margin requirements for selling naked index puts have increased, especially for market-makers, who are the main suppliers of naked puts. Consequently, demand for index puts is high and supply is low. Therefore, out-of-the-money index puts are overly expensive.

This does not entirely explain why index calls are so cheap. Part of the reason for that is that institutional traders can help finance the cost of those expensive index puts by selling some out-of-the-money index calls. Such sales would essentially be covered calls if the institution owned stocks, which it most certainly would. This strategy is called a *collar.*

This distortion in volatilities is not in accordance with the probability distribution of stock prices. These distorted implied volatilities define a different probability curve for stock movement. They seem to say that there is more chance of the market dropping than there is of it rising. This is not true; in fact, just the opposite is true. Refer to the reasons for using lognormal distribution to define stock price movements. Consequently, there are opportunities to profit from volatility skewing, if one is able to hold the position until expiration.

It was shown in previous examples that one would attempt to sell the options with higher implied volatilities and buy ones with lower implieds as a hedge. Hence, for OEX traders, three strategies seem relevant:

1. Buy a bear put spread in OEX.

   Example: Buy 10 OEX June 560 puts
   Sell 10 OEX June 540 puts

2. Buy OEX puts and sell a larger number of out-of-the-money puts—a ratio write of put options.

   Example: Buy 10 OEX June 560 puts
   Sell 20 OEX June 550 puts

3. Sell OEX calls and buy a larger number of out-of-the-money calls—a backspread of call options.

   Example: Buy 20 OEX June 590 calls
   Sell 10 OEX June 580 calls

In all three cases, one is selling the higher implied volatility and buying options with lower implied volatilities. The first strategy is a simple bear spread. While it will benefit from the fact that the options are skewed in terms of implied volatility, it is not a neutral strategy. It requires that the underlying drop in price in order to become profitable. There is nothing wrong with using a directional strategy like this, but the strategist must be aware that the skew is unlikely to disappear (until expiration) and therefore the index price movement is going to be necessary for profitability.

The second strategy would be best suited for moderately bearish investors, although a severe market decline might drive the index so low that the additional short puts could cause severe losses. However, *statistically* this is an attractive strategy. At expiration, the volatility skewing must disappear; the markets will have moved in line with their real probability distribution, not the false one being implied by the skewed options. This makes for a potentially profitable situation for the strategist.

The backspread strategy would work best for bullish investors, although some backspreads can be created for credits, so a little money could also be made if the index fell. In theory, a strategist could implement both strategies simultaneously, which would give him an edge over a wide range of index prices. Again, this does not mean that he cannot lose money; it merely means that his strategy is statistically superior because of the way the options are priced. That is, the odds are in his favor.

In reality, though, a neutral trader would choose either the ratio spread or the backspread—not both. As a general rule of thumb, one would use the ratio spread strategy if the current level of implied volatility were in a high percentile. The backspread strategy would be used if implied volatility were in a *low* percentile currently. In that way, a movement of implied volatility back toward the 50th percentile would also benefit the trade that is in place.

Another interesting thing happens in these strategies that may be to their benefit: The volatility skewing that is present propagates itself throughout the striking prices as OEX moves around. It was shown in the previous section's example that one should probably continue to project his profits using the distorted volatilities that were present when he establishes a position. This is a conservative approach, but a correct one. In the case of these OEX spreads, it may be a benefit.

Assuming that the skewing is present wherever OEX is trading means that the at-the-money strike will have 16% as its implied volatility regardless of the absolute price level; the skewing will then extend out from that strike. So, if OEX rises to 600, then the 600 strike would have a volatility of 16%; or if it fell to 560, then the 560 puts and calls would have a volatility of 16%. Of course, 16% is just a representative figure; the "average" volatility of OEX can change as well. For illustrative purposes, it is convenient to assume that the at-the-money strike keeps a constant volatility.

Example: Initially, a trader establishes a call backspread in OEX options in order to take advantage of the volatility skewing:
Initial situation: OEX: 580

Option	Implied Volatility	Delta
June 590 call	15%	0.40
June 600 call	14%	0.20

A neutral spread would be:

Buy 2 June 600 calls
Sell 1 June 590 call

since the deltas are in the ratio of 2-to-1.

Now, suppose that OEX rises to 600 at a later date, but well before expiration. This is not a particularly attractive price for this position. Recall that, at expiration, a backspread has its worst result at the striking price of the purchased options. Even prior to expiration, one would not expect to have a profit with the index right at 600.

However, the statistical advantage that the strategist had to begin with might be able to help him out. The present situation would probably look like this:

Option	Implied Volatility
June 590 call	17%
June 600 call	16%

The June 600 call is now the at-the-money call, since OEX has risen to 600. As such, its implied volatility will be 16% (or whatever the "average" volatility is for OEX at that time—the assumption is made that it is still 16%). The June 590 call has a slightly higher volatility (17%) because volatility skewing is still present.

Thus, the options that are long in this spread have had their implied volatility *increase*: that is a benefit. Of course, the options that are short had theirs increase as well, but the overall spread should benefit for two reasons:

1. Twice as many options are owned as were sold.
2. The effect of increased volatility is greatest on the at-the-money option; the in-the-money will be affected to a lesser degree.

All index options exhibit this volatility skewing. Volatility skewing exists in other markets as well. The other markets where volatility skewing is prevalent are usually futures option markets. In particular, gold, silver, sugar, soybeans, and coffee options will from time to time display a form of volatility skewing that is the opposite of that displayed by index options. In these futures markets, the cheapest options are out-of-the-money puts, while the most expensive options are out-of-the-money calls.

Example: January soybeans are trading at 580 ($5.80 per bushel). The following table of implied volatilities shows how volatility skewing that is present in the soybean market is the opposite of that shown by the OEX market in the previous examples:

January beans: 580

Strike	Implied Volatility
525	12%
550	13%
575	15%
600	17%
625	19%
650	21%
675	23%

Notice that the out-of-the-money calls are now the more expensive items, while out-of-the-money puts are the cheapest. This pattern of implied volatilities is called *forward volatility skew* or, alternatively, *positive volatility skew.*

The distribution of soybean prices implied by these volatilities is just as incorrect as the OEX one was for the stock market. This soybean implied distribution is too bullish. It implies that there is a much larger probability of the soybean market rising 100 points than there is of it falling 50 points. That is incorrect, considering the historical price movement of soybeans.

A strategist attempting to benefit from the forward (or positive) volatility skew in this market has essentially three strategies available. They are the opposite of the three recommended for the OEX, which had a reverse (or negative) volatility skew. First would be a call bull spread, second would be a put backspread, and third would be a call ratio spread. In all three cases, one would be buying options at the *lower* striking price and selling options at the *higher* striking price. This would give him the theoretical advantage.

The same sorts of comments that were made about the OEX strategies can be applied here. The bull spread is a directional strategy and can probably only be expected to make money if the underlying *rises* in price, despite the statistical advantage of the volatility skew. The put backspread is best established when the overall level of implied volatility is in a low percentile. Finally, the call ratio spread has a great deal of risk to the upside (and futures prices can fly to the upside quickly, especially if bad fundamental conditions develop, such as weather in the grain markets). The call ratio spread would best be used when implied volatilities are already in a high percentile.

As a general comment, it should be noted that if the volatility skew disappears while the trader has the position in place, a profit will generally result. It would normally behoove the strategist to take the profit at that time. Otherwise, follow-up action should adhere to the general kinds of action recommended for the strategies in question: protective action to prevent large losses in the case of the ratio spreads, or the taking of partial profits and possibly rolling the long options to a more at-the-money strike in the case of the backspread strategies.

SUMMARY OF VOLATILITY SKEWING

Whenever volatility skewing exists—no matter what market—opportunities arise for the neutral strategist to establish a position that has advantages. These advantages arise out of the fact that normal market movements are different from what the options are implying. Moreover, the options are wrong when there is skewing at all strikes, from the lowest to the highest. The strategist should be careful to project his profits prior to expiration using the same skewing, for it may persist for some time to come. However, at expiration, it must of course disappear. Therefore, the strategist who is planning to hold the position to expiration will find that volatility skewing has presented him with an opportunity for a positive expected return.

SUMMARY OF VOLATILITY TRADING

The theoretical trading of options, mostly in a neutral manner, has evolved into one large branch—volatility trading. This part of the book has attempted to lay out the foundations, structures, and practices prevalent in this branch of trading. As the reader can see, there are some sophisticated techniques being applied—not so much in terms of strategy, but in terms of the ways that one looks at volatility and in the ways that stocks can move.

Statistical methods are used liberally in trying to determine the ways that either volatility can move or stocks can move. The probability calculators, stock price distributions, and related topics are all statistical in nature. The volatility trader is intent on finding situations in which current market implied volatility is incorrect, either in its absolute value or in the skew that is prevalent in the options on a particular underlying instrument. Upon finding such discrepancies, the trader attempts to take advantage by constructing a more or less neutral position, preferring not to predict price so much, but rather attempting to predict volatility.

Most volatility traders attempt to *buy* volatility rather than sell it, for the reasons that the strategies inherent in doing so have limited risk and large potential rewards, and don't require one to monitor them continuously. If one owns a straddle, any major market movements resulting in gaps in prices are a benefit. Hence, monitoring of positions as little as just once a day is sufficient, a fact that means that the volatility buyer can have a life apart from watching a trading screen all day long. In addition, volatility buyers of stock options can avail themselves of the chaotic movements that stocks can make, taking advantage of the occasional fat tail movements.

However, since volatility and prices are so unstable, one cannot predict their movements with any certainty. The vagaries of historical volatility as compared to implied volatility, the differences between the implied volatility of short- and long-term options, and the difficulty in predicting stock price distributions all complicate the process of predicting volatility. Hence, volatility trading is not a "lock," but its practitioners normally believe that it is by far the best approach to theoretical option trading available today. Moreover, most option professionals primarily trade volatility rather than directional positions.

CHAPTER 40

Advanced Concepts

As the option markets have matured, strategists have been forced to rely more on mathematics in order to select new positions as well as to discern how their positions will behave in fluctuating markets. These techniques can be used on simple strategies, such as bull spreads or ratio spreads, or on far more complex portfolios of options.

First, the concept of implied volatility will be examined in more detail, primarily as an aid in choosing new positions that have a positive expected return. Then, the concept of risk management will be explored. In effect, one can reduce his option position into several components of risk measurement that can be readily understood. This chapter describes the techniques used to evaluate one's position, and shows how to use this information to reduce the risk in the position. The actual mathematical calculations required to perform these analyses are included at the end of the chapter.

NEUTRALITY

In many of the examples in previous chapters, it was generally assumed that one would take a "neutral" position in order to capture the pricing or volatility differential. Why this concentration on neutrality? Neutrality, as it applies to option positions, means that one is noncommittal with respect to at least one of the factors that influence an option's price. Simply put, this means that one can design an option position in which he can profit, no matter which way the underlying security moves.

Most option strategies fall into one of two categories: as a hedge to a stock or futures strategy (for example, buying puts to protect a portfolio of stocks), or as a profit venture unto itself. The latter category is where most traders find themselves, and they often approach it in a fairly speculative manner—either by buying options or by being a premium seller (covered or uncovered). In such strategies, the trader is taking a view of the market; he needs certain price action from the underlying security in order to profit. Even covered call writing, which is considered to be a conservative strategy, is subject to large losses if the underlying stock drops drastically.

It doesn't have to be that way. Strategies can be devised that will have a chance to profit regardless of price changes in the underlying stock, as well as *because* of them. Such strategies are neutral strategies and they always require at least two options in the position—a spread, straddle, or some other combination. Often, when one constructs a neutral strategy, he is neutral with respect to price changes in the underlying security. It is also possible, and often wise, to be neutral with respect to the *rate of price change of the underlying security*, with respect to the *volatility* of the security, or with respect to *time decay*. This is not to imply that any option spread that is neutral will automatically be a moneymaker; rather, one looks for an opportunity—perhaps an overpriced series of options—and attempts to capture that overpricing by constructing a neutral strategy around it. Then, regardless of the movement of the underlying stock, the strategist has a chance of making money if the overpricing disappears.

Note that the neutral approach is distinctly different from the speculator's, who, upon determining that he has discovered an underpriced call, would merely buy the call, hoping for the stock to increase in price. He would not make money if XYZ fell in price unless there was a huge expansion in implied volatility—not something to count on. The next section of this chapter deals with how one determines his neutrality. In effect, if he is not neutral, then he has risk of some sort. The following sections outline various measures of risk that the strategist can use to establish a new position or manage an existing one.

The most important of these risk measurements is how much market exposure the position currently has. This has previously been described as the "delta." Of nearly equal importance to the strategist is how much the option strategy will change with respect to the rate of change in the price of the underlying security. Also of interest are how changes in volatility, in time remaining until expiration, or even in the risk-free interest rate will affect the position. Once the components of the option position are defined, the strategist can then take action to reduce the risk associated with any of the factors, should he so desire.

THE "GREEKS"

Risk measurements have generally been given the names of actual or contrived Greek letters. For example, "delta" was discussed in previous chapters. It has become common practice to refer to the exposure of an option position merely by describing it in terms of this "Greek" nomenclature. For example, "delta long 200 shares" means that the entire option position behaves as if the strategist were merely long 200 shares of the underlying stock. In all, there are six components, but only four are heavily used.

DELTA

The first risk measurement that concerns the option strategist is *how much current exposure his option position has as the underlying security moves*. This is called the "delta." In fact, the term *delta* is commonly used in at least two different contexts: to express the amount by which an option changes for a 1-point move in the underlying security, or to describe the equivalent stock position of an entire option portfolio.

Reviewing the definition of the delta of an individual option (first described in Chapter 3), recall that the delta is a number that ranges between 0.0 and 1.0 for calls, and between –1.0 and 0.0 for puts. It is the amount by which the option will move if the underlying stock moves 1 point; stated another way, it is the percentage of any stock price change that will be reflected in the change of price of the option.

Example: Assume an XYZ January 50 call has a delta of 0.50 with XYZ at a price of 49. This means that the call will move 50% as fast as the stock will move. So, if XYZ jumps to 51, a gain of 2 points, then the January 50 call can be expected to increase in price by 1 point (50% of the stock increase).

In another context, the delta of a call is often thought of as the probability of the call being in-the-money at expiration. That is, if XYZ is 50 and the January 55 call has a delta of 0.40, then there is a 40% probability that XYZ will be over 55 at January expiration.

Put deltas are expressed as negative numbers to indicate that put prices move in the opposite direction from the underlying security. Recall that deltas of out-of-the-money options are smaller numbers, tending toward 0 as the option becomes very far out-of-the-money. Conversely, deeply in-the-money calls have deltas approaching 1.0, while deeply in-the-money puts have deltas approaching –1.0. Note: Mathematically, the delta of an option is the partial derivative of the Black–Scholes equation (or whatever formula one is using) with respect to stock price. Graphically, it is the slope of a line that is tangent to the option pricing curve.

Let us now take a look at how both volatility and time affect the delta of a call option. Much of the data to be presented in this chapter will be in both tabular and graphical form, since some readers prefer one style or the other.

The volatility of the underlying stock has an effect on delta. If the stock is not volatile, then in-the-money options have a higher delta, and out-of-the-money options have a lower delta. Figure 40-1 and Table 40-1 depict the deltas of various calls on two stocks with differing volatilities. The deltas are shown for various strike prices, with the time remaining to expiration equal to 3 months and the underlying stock at a price of 50 in all cases. Note that the graph confirms the fact that a low-volatility stock's in-the-money

FIGURE 40-1.
Delta comparison, with XYZ = 50.

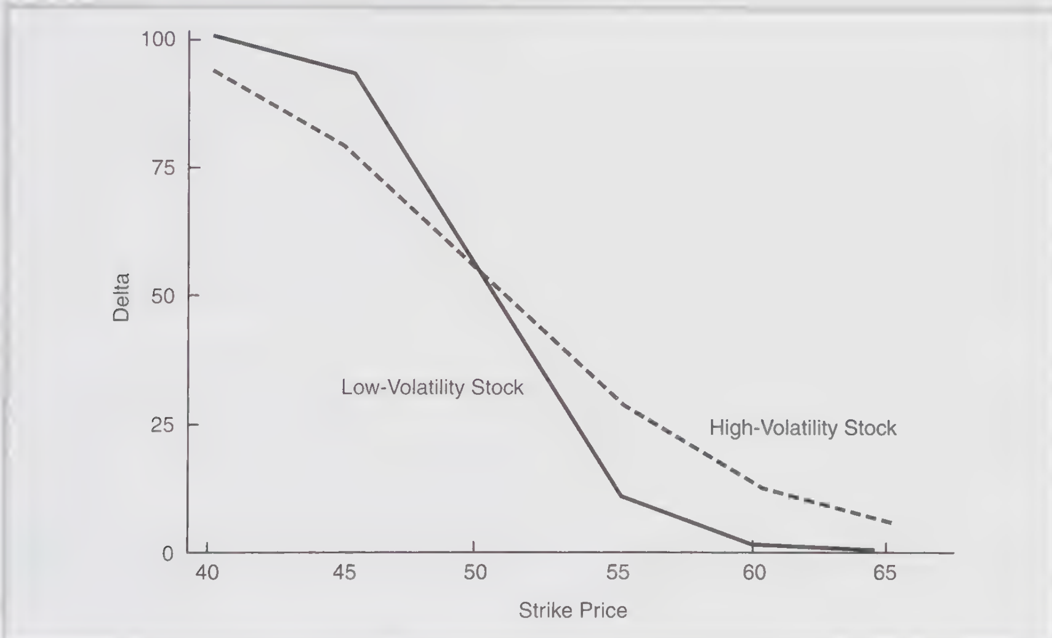


TABLE 40-1.
Delta comparison for different volatilities with XYZ = 50 and time = 3 months.

	Delta	
Strike Price	Low-Volatility Stock	High-Volatility Stock
40	100	94
45	93	78
50	51	53
55	11	29
60	1	13
65	0	5

options have the higher delta. The opposite holds true for out-of-the-money options: The high-volatility stock's options have the higher delta in that case. Another way to view this data is that a higher-volatility stock's options will always have more time value premium than the low-volatility stock's. In-the-money, these options with more time value will not track the underlying stock price movement as closely as ones with little or no time value. Thus, in-the-money, the low-volatility stock's options have the higher delta, since they track the underlying stock price movements more closely. Out-of-the-money, the entire price of the option is composed of time value premium. The ones with higher time value (the ones on the high-volatility stock) will move more since they have a higher price. Thus, out-of-the-money, the higher-volatility stock's options have the greater delta.

Time also affects delta. Figures 40-2 (see Table 40-2) and 40-4 show the relationships between time and delta. Figure 40-2's scales are similar to those in Figure 40-2, delta vs. volatility: The deltas are shown for various striking prices, with XYZ assumed to be equal to 50 in all cases. Notice that in-the-money, the shorter-term options have the higher delta. Again, this is because they have the least time value premium. Out-of-the-money, the opposite is true: The longer-term options have the higher deltas, since these options have the most time value premium.

Figure 40-3 (see Table 40-3) depicts the delta for an XYZ January 50 call with XYZ equal to 50. The horizontal axis in this graph is "weeks until expiration." Note that the delta of a longer-term at-the-money option is larger than that of a shorter-term option. In fact, the delta shrinks more rapidly as expiration draws nearer. Thus, even if a stock remains unchanged and its volatility is constant, the delta of its options will be altered as time passes. This is an important point to note for the strategist, since he is constantly monitoring the risk characteristics of his position. He cannot assume that his position is the same just because the stock has remained at the same price for a period of time.

Position Delta. Another usage of the term *delta* is what has previously been referred to as the equivalent stock position (ESP); for futures options, it would be referred to as EFP (equivalent futures position). To differentiate between the two terms, the delta of the option is generally referred to as "option delta," while the ESP or EFP is called "position delta." Recall that the position delta is computed according to the following simple equation:

$$\text{Position delta} = \text{Option's delta} \times \text{Shares per option} \times \text{Option quantity}$$

For futures options, the term "shares per option" would be replaced by "shares per contract." which is always 1. This is the risk measurement of how much market exposure the options position has. Whether called position delta, ESP, or EFP, one uses the deltas of the individual options in his portfolio to calculate the overall exposure. By summing

FIGURE 40-2.
Delta comparison, with XYZ = 50.

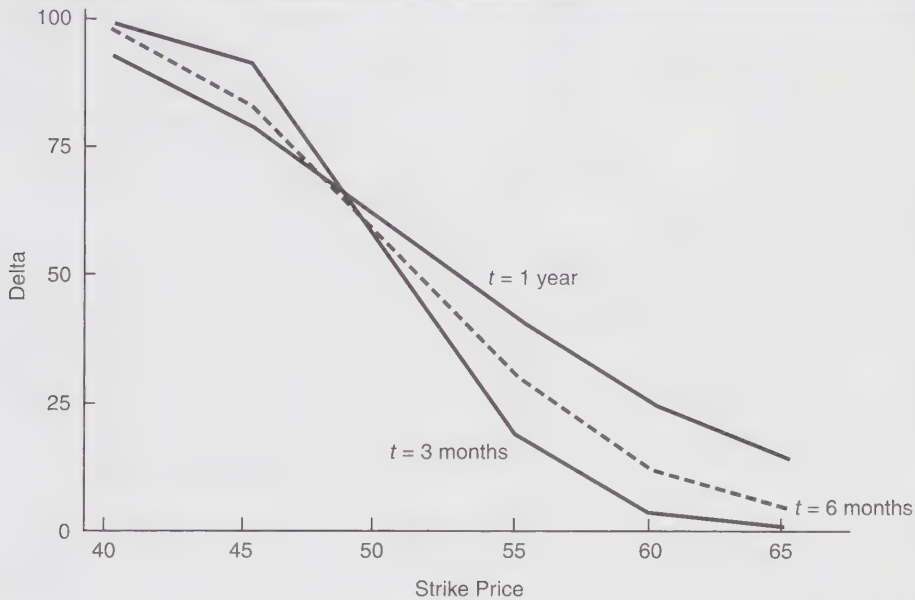


TABLE 40-2.
Delta comparison—varying time remaining with XYZ = 50.

	Delta		
Strike Price	t = 1 year	t = 6 months	t = 3 months
40	92	97	99
45	79	83	90
50	61	57	55
55	41	30	18
60	25	12	3
65	14	4	0

the calculations for each item in a position, or even in an entire option portfolio, one can approximate how much market exposure the entire option position has. The next example, reprinted from the chapter on mathematical applications, shows how one computes the net exposure of a complicated position.

FIGURE 40-3.
Delta as a function of time.

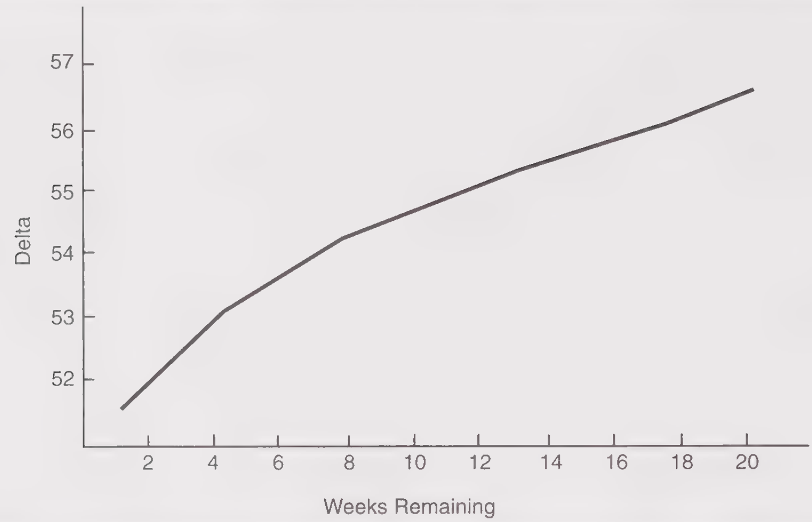


TABLE 40-3.
Delta as a function of time.

Weeks Remaining	Delta
20	.566
18	.562
15	.557
13	.553
10	.547
8	.543
6	.538
4	.531
2	.521
1	.515

Example: The following position exists when XYZ is at 31.75. It resembles a long straddle (or backspread), in that there is increased profit potential in either direction if the stock moves far enough by expiration. Many market-makers and professional traders attempt to structure these types of positions, if possible, in order to take advantage of the sudden volatility that is inherent in today's markets.

Position	Delta	Position Delta
Short 4,500 XYZ	1.00	– 4,500
Short 100 XYZ April 25 calls	0.89	– 8,900
Long 50 XYZ April 30 calls	0.76	+ 3,800
Long 139 XYZ July 30 calls	0.74	+10,286
	Total ESP:	+ 686

This position, though complicated to the naked eye, reduces to being long only approximately 700 shares of XYZ. This is commonly referred to as being "delta long 700 shares." Thus, the terms "delta," when referring to the sum of the deltas of a whole position, and "equivalent stock position" are synonymous.

This position has some exposure to the market since it is delta long. If the position delta were zero, it would be referred to as being delta neutral and would, theoretically, have no exposure to the market at that time.

Note that one can derive some general characteristics of his delta by just examining his portfolio by eye: Short calls or long puts will introduce negative delta into the position; long calls or short puts will introduce positive delta. Furthermore, it is obvious that being long the underlying security adds to the long delta of the position, while being short the underlying security places more negative delta in the position. The use of this information to adjust the delta of one's position will be discussed in a later section of this chapter.

Obviously, the delta of this entire position will change as the stock price moves up or down as time passes. The figure given is merely an instantaneous look at how the position is structured. It is the need to know how the position will change when other factors change that has led strategists to employ the following concepts.

GAMMA

Simply stated, *the gamma is how fast the delta changes* with respect to changes in the underlying stock price. It is known that the delta of a call increases as the call moves from out-of-the-money to in-the-money. The gamma is merely a precise measurement of how fast the delta is increasing.

Example: With XYZ at 49, assume the January 50 call has a delta of 0.50 and a gamma of 0.05. If XYZ moves up one point to 50, the delta of the call will increase by the amount of the gamma: It will increase from 0.50 to 0.55.

As with the delta, the gamma can also be expressed as a percentage. But in this case, the increase or decrease applies to the delta.

Example: Again, with XYZ at 49, assume the January 50 call has a delta of 0.50 and a gamma of 0.05. If XYZ moves up 2 points to 51, the delta of the call will increase by 5% of the *stock move*, because the *gamma* is 0.05, or 5 percent. Five percent of the *stock move* is 0.05×2, or 0.10. Thus, the delta will increase by 0.10, from 0.50 to 0.60.

Obviously, the delta cannot keep increasing by 0.05 each time XYZ gains another point in price, for it will eventually exceed 1.00 by that calculation, and it is known that the delta has a maximum of 1.00. Thus, it is obvious that the gamma changes. In general, *the gamma is at its maximum point when the stock is near the strike of the option.* As the stock moves away from the strike in either direction, the gamma decreases, approaching its minimum value of zero.

Conceptually, this means that a deeply in-the-money or deeply out-of-the-money option has a *gamma* of nearly zero. This makes sense—it implies that the *delta* of a deep in- or deep out-of-the-money option does not change very much at all, even if the stock moves by one point.

Example: Assume XYZ is 25, and the January 50 call has a delta of virtually zero. If XYZ moves up one point to 26, the call is still so far out-of-the-money that the delta will still be zero. Thus, the gamma of this call is zero, since the delta does not change when the stock increases in price by a point.

In a similar manner, the January 45 put on XYZ would have a delta of –1.0 with XYZ at 25. If XYZ moved up one point to 26, the put's delta would not change; it is still so far in-the-money that it would still be –1.0. Thus, the gamma of this deeply in-the-money option is also zero, since the delta remains unchanged in the face of a 1-point rise in the underlying security.

Note that the gamma of any option is expressed as a positive number, whether the option is a put or a call.

Other properties of gamma are useful to know as well. As expiration nears, the gamma of at-the-money options increases dramatically. Consider an option with a day or two of life remaining. If it is at-the-money, the delta is approximately 0.50. However, if the stock were to move 2 points higher, the delta of the option would jump to nearly 1.00 because of the short time remaining until expiration. Thus, the gamma would be roughly 0.25 (the delta increased by 0.50 when the stock moved 2 points), as compared to much smaller values of gamma for at-the-money options with several weeks or months of life remaining. The same 2-point rise in the underlying stock would not result in much of an increase in the delta of longer-term options at all.

Out-of-the-money options display a different relationship between gamma and time remaining. An out-of-the-money option that is about to expire has a very small delta, and hence a very small gamma. However, if the out-of-the-money option has a significant amount of time remaining, then it will have a larger gamma than the option that is close to expiration.

Figure 40-4 (see Table 40-4) depicts the gammas of three options with varying amounts of time remaining until expiration. The properties regarding the relationship of gamma and time can be observed here. Notice that the short-term options have very low gammas deeply in- or out-of the-money, but have the highest gamma at-the-money (at 50). Conversely, the longest-term, one-year option has the highest gamma of the three time periods for deeply in- or out-of-the-money options. The data is presented in Table 40-4. This table contains a slight amount of additional data: the gamma for the at-the-money option at even shorter periods of time remaining until expiration. Notice how the gamma explodes as time decreases, for the at-the-money option. With only one week remaining, the gamma is over 0.28, meaning that the delta of such a call would, for example, jump from 0.50 to 0.78 if the stock merely moved up from 50 to 51.

Gamma is dependent on the volatility of the underlying security as well. At-the-money options on less volatile securities will have higher gammas than similar options on more volatile securities. The following example demonstrates this fact.

Example: Assume XYZ is at 49, as is ABC. Moreover, XYZ is a more volatile stock (30% implied) as compared to ABC (20%). Then, similar options on the two stocks would have significantly different gammas.

Option	XYZ Gammas (Volatility = 30%)	ABC Gammas (Volatility = 20%)
January 50	.066	.097
January 55	.045	.039
January 60	.019	.0053
February 50	.055	.081
February 60	.024	.011

Note that the at-the-money options (January 50's and February 50's) on ABC, the less volatile stock, have larger gammas than do their XYZ counterparts. However, look one strike higher (January 55's), and notice that the more volatile options have a slightly

FIGURE 40-4.
Gamma comparison, with XYZ = 50.

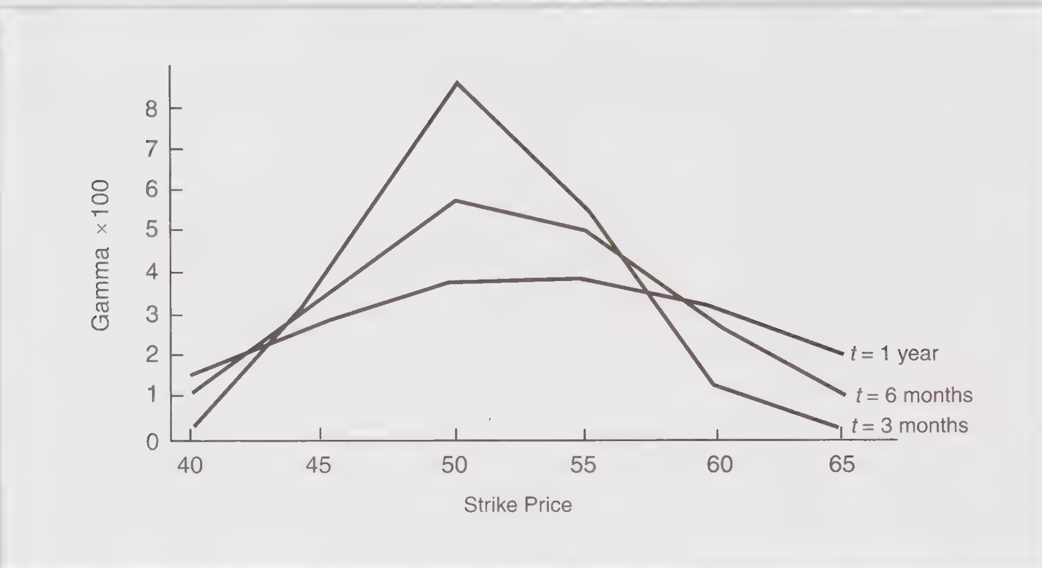


TABLE 40-4.
Gamma comparison—various amounts of time remaining (with XYZ = 50).

Time Remaining	Strike Price					
	40	45	50	55	60	65
1 year	.015	.029	.039	.04	.033	.023
6 months	.011	.037	.058	.051	.030	.013
3 months	.003	.039	.086	.057	.015	.002
2 months			.108			
1 month			.166			
1 week			.288			

higher gamma. Look two strikes higher and the more volatile options have a vastly higher gamma, both for the January 60's and the February 60's.

This concept makes sense if one thinks about the relationship between volatility and delta. On nonvolatile stocks, one finds that the delta of even a slightly in-the-money option increases rapidly. This is because, since the stock is not volatile, buyers are not willing to pay much time premium for the option. As a result, the gamma is high as well, because as the stock moves into-the-money, the *increase* in delta will be more dramatic than it would be for a volatile stock. Out-of-the-money options are an entirely different story. Since the nonvolatile stock will have difficulty moving fast enough to reach an out-of-the-money striking price, the delta of the out-of-the-money option is small and it will not change quickly (that is, the gamma is small also).

These concepts are summarized in Figure 40-5 (see Table 40-5), which depicts the gammas for similar options on stocks with differing volatilities. For the purposes of these graphs, XYZ is equal to 50 and there are three months remaining until expiration.

Notice that for a very volatile stock, the gamma is quite stable over nearly all striking prices when there are 3 months remaining until expiration. This means that the deltas of all options on such a volatile stock will be changing quite a bit for even a 1-point move in the underlying stock. This is an important point for neutral strategists to note, because a position that starts out as delta neutral may quickly change if the underlying stock is very volatile. As this table implies, the deltas of the options in that "neutral" spread may be altered quickly, thereby rendering the spread quite unneutral. This concept will be discussed in greater detail later in this chapter.

As delta was used to construct the equivalent stock position of an entire option position or portfolio, gamma can be used in a similar manner. An example of this follows, using the same securities from the preceding example on the delta of a position. An important point to note is that *the gamma of the underlying security itself is zero.* This is

FIGURE 40-5.
Gamma comparison, with XYZ = 50, t = three months.

TABLE 40-5.
Gamma comparison for varying volatilities (XYZ = 50, t = 3 months).

Strike	Low Volatility	Gamma High Volatility	Very High Volatility
40	.003	.013	.017
45	.039	.039	.022
50	.086	.057	.024
55	.057	.049	.025
60	.015	.028	.023
65	.002	.012	.020

true because the *delta* of the underlying security (which is always 1.0) never changes—hence the gamma is zero. The gamma is measuring the amount of change of the delta; if the delta of the underlying security never changes, the gamma of the underlying security must be zero.

Example: The following position exists when XYZ is at 31.75. Recall that it resembles a long straddle (or backspread) in that there is increased profit potential in either direction if the stock moves far enough by expiration. In addition to the delta previously listed, the gamma is now shown as well. Note that since gamma is a small absolute number, it is sometimes calculated out to three or four decimal places.

Position	Option Delta	Position Delta	Option Gamma	Position Gamma
Short 4,500 XYZ	1.00	– 4,500	0.0000	0
Short 100 XYZ April 25 calls	0.89	– 8,900	0.0100	–100
Long 50 XYZ April 30 calls	0.76	+ 3,800	0.0300	+150
Long 139 XYZ July 30 calls	0.74	+10,286	0.0200	+278
Totals:		+ 686		+328

As before, the position still has a delta long of almost 700 shares. In addition, one can now see that it has a *positive gamma* of over 300 shares. This means that the delta can be expected to change by 328 shares for each point that XYZ moves: If it moves up 1 point, the delta will increase to +1,014 (the current delta, 686, plus the gamma of 328). However, if XYZ moves down by 1 point, then the delta will decrease to +358 (the current delta, 686, less the gamma of 328).

* * *

Note that, in the above example, if XYZ continues higher, the gamma will remain positive (although it will eventually shrink some), and the delta will continue to increase. This means the position is getting longer and longer—a fact that makes sense when one notes that there are extra long calls and they would be getting deeper in-the-money as the stock moves up. Conversely, if XYZ continues to move lower, the delta will continue to decrease and will quickly become negative, meaning that the position would become short overall. Hence, the position does indeed resemble a long straddle: It gets longer as the market moves up and it gets shorter as the market moves down.

Long options, whether puts or calls, have positive gamma, while short options have negative gamma. Thus, a strategist with a position that has positive gamma has a net long option position and is generally hoping for large market movements. Conversely, if one has a position with negative gamma, it means he has shorted options and wants the market to remain fairly stable.

Note that it is possible to be delta neutral, but to have a significant gamma. (For example, if one owns puts and calls with offsetting deltas, he would be delta neutral, but would have positive gamma since both options are long.) If one is delta neutral, he knows he has no market exposure at this time, but his gamma will show him what exposure his position will acquire as the market moves. These concepts will be discussed in greater detail later in this chapter.

VEGA OR TAU

There is no letter in the Greek alphabet called "vega." Thus, some strategists, being purists, prefer to use a real Greek letter, "tau," to refer to this risk measurement. The term "vega" will be used in this book, but the reader should note that "tau" means the same thing. *Vega is the amount by which the option price changes when the volatility changes.* Vega is always expressed as a positive number, whether it refers to a put or a call.

It is known that more volatile stocks have more expensive options. Thus, as volatility increases, the price of an option will rise. If volatility falls, the price of the option will fall as well. The vega is merely an attempt to quantify how much the option price will increase or decrease as the volatility moves, all other factors being equal.

Before considering an example, a review of the term *volatility* is in order. Volatility is a measure of how quickly the underlying security moves around. Statistically, it is usually calculated as the standard deviation of stock prices over some period of time, generally annualized. This statistical measure is expressed as a percent, although relating that percent to actual stock movements can be complicated. Suffice it to say that a stock that has a 50% volatility is more volatile than a stock with 30% volatility. The stock market generally has a volatility of about 15% overall, although that may change from time to time (crashes, for example).

Example: Again, assume XYZ is at 49, and the January 50 call is selling for 3.50. The vega of the option is 0.25, and the current volatility of XYZ is 30%.

If the volatility increases by one percentage point or 1% to 31%, then the vega indicates that the option will increase in value by 0.25, to 3.75.

If the volatility had instead decreased by 1 percent to 29%, then the January 50 call would have decreased to 3.25 (a loss of 0.25, the amount of the vega).

If the implied volatility of an option increases, the option price will increase as well. Consequently, even though XYZ stock may be exhibiting the same historic movement that it always has, and therefore its (historical) volatility would be unchanged, if option buyers appear in sufficient quantity, they may drive the implied volatility of XYZ's options higher. Likewise, an excess of option sellers could drive the implied volatility lower, even though the historical volatility does not change. So, it must be concluded that *vega measures how much the option price changes as implied volatility changes.*

Vega is related to time. Figure 40-6 (see Table 40-6) shows the vegas for options with differing times remaining until expiration. The underlying stock is assumed to be 50 in all cases. Notice that the more time that remains, the higher the vega is. It is interesting to note that, for very long-term options, the vega of the slightly out-of-the-money calls (strike = 55) is actually higher than that of the at-the-money. However, this discrepancy disappears as time passes. Not shown, but equally true, is that the vega of a slightly out-of-the-money option on a very volatile stock may be higher than that of the at-the-money.

As with the measurements of risk discussed already, vega can refer to the option itself ("option vega") or to the position as a whole ("position vega"). Since vega is expressed as a positive number, if one is long options, then his position vega will be positive. This means he has exposure if volatilities decrease, or can make money if volatilities increase.

Example: Again, assume that we have the same backspread position as before, with XYZ at 31.75.

Position	Option Vega	Position Vega
Short 4,500 XYZ	0.00	0
Short 100 XYZ April 25 calls	0.02	− 200
Long 50 XYZ April 30 calls	0.05	+ 250
Long 139 XYZ July 30 calls	0.07	+ 973
Total Vega:		+1,023

FIGURE 40-6.
Vega comparison, XYZ = 50.

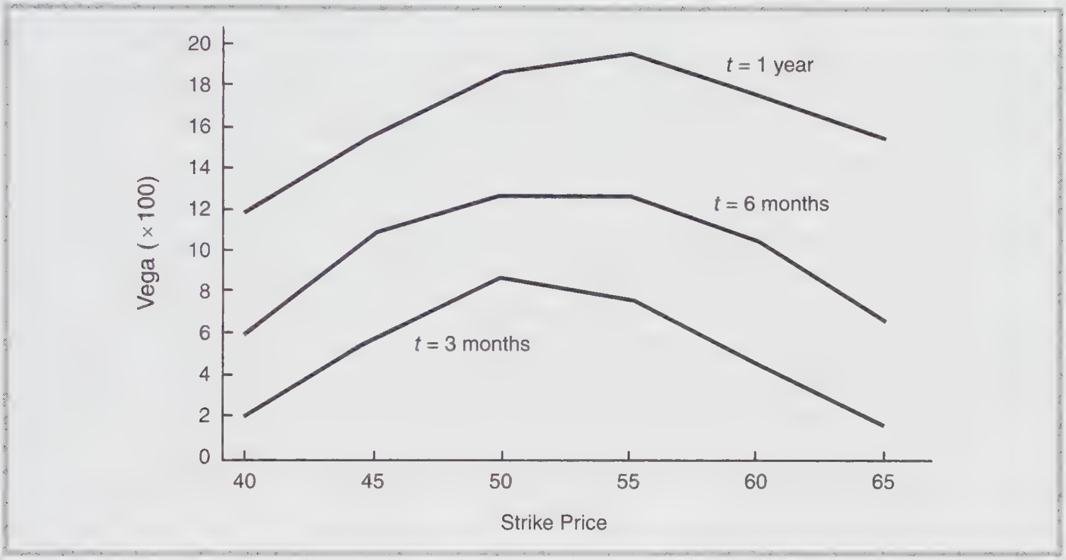


TABLE 40-6.
Vega comparison for different time periods (with XYZ = 50).

	Vega		
Strike Price	t = 1 Year	t = 6 Months	t = 3 Months
40	0.12	0.06	0.02
45	0.16	0.11	0.06
50	0.19	0.13	0.09
55	0.20	0.13	0.08
60	0.18	0.11	0.05
65	0.16	0.07	0.02

The vega is a positive 10.23 points ($1,023 since each point for these equity options is worth $100). The fact that the position has a positive vega means that it is exposed to variations in volatility. If volatility decreases, the position will lose money: $1,023 for each one percentage point decrease in volatility. However, if volatility increases, the position will benefit.

* * *

Vega is greatest for at-the-money options and approaches zero as the option is deeply in- or out-of-the-money. Again, this is common sense, since a deep in- or out-of-the-money option will not be affected much by a change in volatility. In addition, for at-the-money options, longer-term options have a higher vega than short-term options. To verify this, think of it in the extreme: An at-the-money option with one day to expiration will not be overly affected by any change in volatility, due to its pending expiration. However, a three-month at-the-money option will certainly be sensitive to changes in volatility.

Vega does not directly correlate with either delta or gamma. One could have a position with no delta and no gamma (delta neutral and gamma neutral) and still have exposure to volatility. This does not mean that such a position would be undesirable; it merely means that if one had such a position, he would have removed most of the market risk from his position and would be concerned only with volatility risk.

In later sections, the use of volatility to establish positions and the use of vega to monitor them will be discussed.

THETA

Theta measures the time decay of a position. All option traders know that time is the enemy of the option holder, and it is the friend of the option writer. Theta is the name given to the risk measurement of time in one's position. Theta is generally expressed as a negative number, and it is expressed as the amount by which the option value will change. Thus, if an option has a theta of −0.12, that means the option will lose 12 cents, or about an eighth of a point, *per day*. This is true for both puts and calls, although the theta of a put and a call with the same strike and expiration date are not equal to each other.

Very long-term options are not subject to much time decay in one day's time. Thus, the theta of a long-term option is nearly zero. On the other hand, short-term options, especially at-the-money ones, have the largest absolute theta, since they are subject to the ravages of time on a daily basis. The theta of options on a highly volatile stock will be higher than the theta of options on a low-volatility stock. Obviously, the former options are more expensive (have more time value) and therefore have more time value to lose on a daily basis, thereby implying that they have a higher theta. Finally, the decay is not linear—an option will lose a greater percent of its daily value near the end of its life.

Figure 40-7 (see Table 40-7) depicts the relationships of thetas for various striking prices and for differing volatilities on options with three months of life remaining. Again, notice that for very volatile stocks, the out-of-the-money options have thetas as large as the at-the-moneys. This is saying that as each day passes, the probability of the stock

FIGURE 40-7.
Theta comparison, with XYZ = 50, t = three months.

TABLE 40-7.
Theta comparison for differing volatilities (XYZ = 50, t = 3 months).

Strike	Low Volatility	Medium Volatility	High Volatility
40	–0.005	–0.008	–0.013
45	–0.007	–0.010	–0.014
50	–0.008	–0.010	–0.015
55	–0.007	–0.010	–0.016
60	–0.006	–0.009	–0.016
65	–0.004	–0.008	–0.015

reaching that out-of-the-money strike drops and causes the option to lose value. This does not change the fact that, for very short-term options, the theta is largest at-the-money.

Normally, the theta of an individual option is of little interest to the strategist. He generally would be more concerned with delta or gamma. However, as with the other risk measures, theta can be computed for an entire portfolio of options. This measure, the "position theta," can be quite important because it gives the strategist a good idea of how much gain or loss he can expect on a daily basis, due to time erosion. The following example demonstrates this point. Note that the underlying security itself has a theta of zero, since it cannot lose any value due to time decay.

Example: With XYZ at 49, the strategist has the following position in February, so that the April calls are nearer to expiration than the July calls. This position is similar to a large calendar spread position.

Position	Option Theta	Position Theta
Short 4,000 XYZ	0.00	0
Short 150 XYZ April 50 calls	–0.04	+600
Long 150 XYZ April 30 calls	–0.02	–300
Short 78 XYZ July 30 puts	–0.02	+156
Total Theta:		+456

This position is expected to make $456 per day due to time decay. Note that *short options, whether puts or calls, have a positive position theta, while long options have a negative position theta*. A negative position theta means the position has risk due to time, while a positive position theta means time is working for the position.

RHO

Rho is the name given to the *price change of an option's value due to a change in interest rates*. Recall that one of the components that contributes to an option's price is interest rates. *As interest rates rise, call prices will rise, but put prices will fall. The opposite is true as well: As interest rates fall, call prices decline and put prices rise.* Rho measures the amount by which these prices rise or fall.

This behavior of puts and calls with respect to interest rates may not be immediately obvious, but recall that the arbitrage that can be established with in-the-money calls (the "interest play," discussed in Chapter 27 on arbitrage) demonstrates that arbitrageurs are willing to pay more for an in-the-money call as interest rates rise because they will be earning more interest on the stock that they sell short against that in-the-money call. Thus, rising interest rates cause call prices to increase.

The opposite is true for puts: Rising interest rates cause put prices to decline. Again, an arbitrage can be used to demonstrate the point. Recall that in a reversal arbitrage, the arbitrageur is selling the stock and the put while buying the call. We have just demonstrated that, as interest rates rise, he is willing to pay more for the call since he can earn extra interest on the short sale of his stock. This automatically means that he will be willing to sell the put for less.

Rho is expressed as a positive number for calls and a negative one for puts. *Rho is smallest for deeply out-of-the-money options and is large for deeply in-the-money options. It is larger for longer-term options and is nearly zero for very short-term options.* The following table of option prices may help to demonstrate these relationships:

Example: With XYZ at 49, the following options have the rho indicated (January is the near-term expiration):

Month/Strike	Call Rho	Put Rho
January 35	0.05	–0.01
January 50	0.03	–0.03
January 60	0.00	–0.05
July 35	0.18	–0.02
July 50	0.14	–0.15
July 60	0.07	–0.18

Note that the in-the-money calls (35 strike) have larger rho than the out-of-the-money 60's, in both January and July. Similarly, the in-the-money puts (the 60's) have larger rho on an absolute basis than the out-of-the-money 35's. Again, this is true for both January and July.

Furthermore, note that the longer-term July rhos are all larger (again as absolute numbers) than their shorter-term January counterparts.

Rho can also be calculated for an entire portfolio to obtain a "position rho," similar to previous examples. Generally, one would not be overly concerned with his position rho unless his portfolio contained quite a few long-term options and/or deeply in-the-money ones. Thus, rho is more important as a consideration when one is trading LEAPS or warrants, both of which may be extremely long-term vehicles. Of the risk measures discussed so far, rho is the least used, since many traders tend to have relatively short-term options in their positions.

THE GAMMA OF THE GAMMA

Occasionally, one may hear reference to the "six measures of risk." This is the sixth one and it is the most arcane. At any point, one knows the delta and gamma of an option. As the stock moves, the delta changes (by the amount of the gamma), but so does the gamma. Some traders are interested in knowing how much the *gamma* will change when the stock moves. Hence, they will compute the *gamma of the gamma*, which is *the amount by which the gamma will change when the stock price changes.* This concept will be discussed at the end of this chapter. It is most important for strategists involved in positions on highly volatile stocks, for if the stock moves far enough, the gamma (and therefore the delta) may change dramatically. Thus, one might want to know how this risk measure affects his profitability.

SUMMARY

Delta: Positive delta indicates that a position is currently bullish; if the underlying security goes up in price, the position should make money. A negative delta indicates a bearish slant.

Gamma: Positive gamma means that the delta will increase if the underlying security rises in price. Positive gamma generally implies that there is a preponderance of long options in the position, either puts or calls; negative gamma indicates written or naked options in the position.

Theta: Negative theta means that the position will lose money as time passes (typical of positions with long options); positive theta implies that time is working for the position (positions with written options).

Vega: Positive vega means that an increase of (perceived) volatility will benefit the position—usually true of positions with long options in them; negative vega means that a decrease of volatility would be beneficial.

STRATEGY CONSIDERATIONS: USING THE "GREEKS"

Before looking at how one operates a particular strategy using delta, gamma, etc., it might be beneficial to see how these factors relate to the individual strategies that have been described throughout this book. Table 40-8 is a general guide to how the various strategies are exposed to various market factors. It is not an all-purpose or specific table, because as the stock moves higher or lower, some of the risk measurement factors will certainly be affected.

A few assumptions were made in constructing the table. First, it was assumed that the strategies where delta is noted as being zero are established in a neutral stance. The bull spread and bear spread strategies assumed that the stock was midway between the striking prices. Two other spread strategies—ratio call and ratio put—assumed the stock was at the striking price of the option that was sold. In all other cases, there is only one striking price involved, and it was assumed that the stock was at the strike.

TABLE 40-8.
General risk exposure of common strategies.

Strategy	Delta	Gamma	Theta	Vega	Rho
Buy stock	+	0	0	0	0
Sell stock short	–	0	0	0	0
Call buy	+	+	–	+	+
Put buy	–	+	–	+	–
Straddle buy	0	+	–	+	+
Covered write	+	–	+	–	–
Naked call sale	–	–	+	–	–
Naked put sale	+	–	+	–	+
Ratio write (straddle sale)	0	–	+	–	–
Calendar spread	0	–	+	+	–
Bull spread	+	–	–	–	+
Bear spread	–	–	–	–	+
Ratio call spread	0	–	+	–	–
Ratio put spread	0	–	+	–	+

The table may help to clarify some of the concepts concerning the risk measurement factors. First, notice that stock or futures—or any underlying security—have only delta. None of the other factors pertains to the underlying security itself.

As might be expected, spread strategies involving both long and short options are less easily quantified than outright buys or sells. The calendar spread strategy is one in which the spreader does not want a lot of stock movement—he would prefer the underlying security to remain near the striking price, for that is the area of maximum profit potential. This is reflected by the fact that gamma is negative. Also, for calendar spreads, the passage of time is good, a fact that is reflected by the fact that theta is positive. Finally, since an increase in implied volatilities or interest rates would boost prices and widen the spread (creating a profit), vega is positive and rho is negative.

A bull spread has positive delta, reflecting the bullish nature of the spread, but it has negative gamma. The reason gamma is negative is that the position becomes less bullish as the underlying security rises, since the profit potential, and hence the bullishness of the position, is limited. For similar reasons, a bear spread has negative delta (reflecting bearishness) and negative gamma (reflecting limited bearishness). Both the bull spread and the bear spread are the same with respect to the other risk measurements: Theta is negative, reflecting the fact that time decay can hurt the spread. Less obvious is the fact that these spreads are hurt by an increase in perceived volatility; a negative vega tells us this is true, however.

These risk measurement tools are important in that they can quite graphically depict the risk and reward characteristics of an option position or option portfolio. They are useful in establishing a new position, because one can see how much exposure he is taking on. In addition, they are extremely useful for follow-up action, since one can see how his position's characteristics have developed in the current marketplace at the present time. In the following sections, the use of the risk measurement tools as aids in establishing a position or in following up on a position will be discussed in detail.

DELTA NEUTRAL

One popular type of neutral position is to be *delta neutral*—that is, to have the equivalent stock position (ESP) or equivalent futures position (EFP) be zero. *A delta neutral position is one in which the sum of the projected price changes of the long options in the spread is essentially offset by the projected price changes of the short options in the same spread.*

Example: XYZ is trading at 50. The following three options are trading with the prices and deltas indicated. Furthermore, the "theoretical value" of each option is shown:

XYZ: 50

Option	Price	Delta	"Theoretical Value"
January 50 call	3.00	0.55	3.50
January 55 call	1.50	0.35	1.48
February 50 put	3.50	–0.40	3.44

Assuming that one can rely upon these "theoretical values" (a big assumption, by the way), it is obvious that the January 50 call is cheap with respect to the other options: They are close to their values, while the January 50 is 50 cents under. The neutral strategist would want to buy the January 50 call and hedge his purchase with one of the other two options presented. One choice would be to establish a spread wherein the January 50 calls are bought and a number of January 55's are sold. To determine how many are to be bought and sold, one merely has to divide the deltas of the two options:

$$\text{Delta neutral spread ratio} = 0.55/0.35 = 11\text{-to-}7$$

Thus, a delta neutral ratio spread would consist of buying 7 January 50's and selling 11 January 55's. To verify that this spread is neutral with respect to the change in price of

XYZ, notice that if XYZ moves up in price 1 point, the January 50 will increase in price by 0.55; so seven of them will increase by 7×0.55, or 3.85 points total. Similarly, the January 55 will increase in price by 0.35, so eleven of them would increase in price by 11×0.35, or 3.85 points total. Hence, the long side of the spread would profit by 3.85 points, while the short side loses 3.85 points—a neutral situation.

The resulting position is a ratio spread. The profitability of the spread occurs between about 51 and 62 at expiration as shown in Figure 40-8, but that is not the major point. The real attractiveness of the spread to the neutral trader is that if the underpriced nature of the January 50 call (vis-à-vis the January 55 call) should disappear, the spread should produce a profit, regardless of the short-term market movement of XYZ. The spread could then be closed if this should occur.

To illustrate this fact, suppose that XYZ actually falls to 49, but the January 50 call returns to "fair value":

XYZ: 49

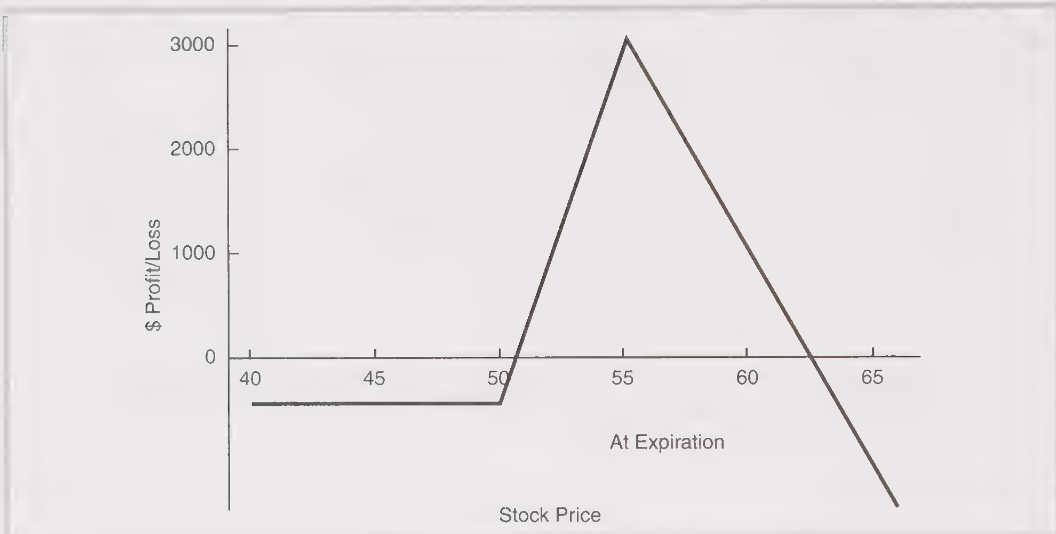
Option	Price	Delta	"Theoretical Value"
January 50 call	3.00	0.52	3.00
January 55 call	1.10	0.34	1.13
February 50 put	3.90	–0.42	3.84

Notice that the theoretical values in this table are equal to the theoretical values from the previous table, less the amount of the delta. Since the XYZ January 50 call is no longer underpriced, the position would be removed, and the strategist would make nothing on his January 50's, but would make .40 on each of the eleven short January 55's, for a profit of $440 less commissions.

This example leans heavily on the assumption that one is able to accurately estimate the theoretical value and delta of the options. In real life, this chore can be quite difficult, since the estimate requires one to define the future volatility of the common stock. This is not easy. However, for the purposes of a spread, the ratio of the two deltas is used. Moreover, the example didn't require that one know the exact theoretical value of each option; rather, the only knowledge that was required was that one of the options was cheap with respect to the other options.

As an alternative to a ratio spread, another type of delta neutral position could be established from the previous data: Buy the January 50 call (this is the basis of the position since it is supposedly the cheap option) and buy the February 50 put—the only other choice from the

FIGURE 40-8.
XYZ ratio spread.



data given. This position is a long straddle of sorts. Recall that the delta of a put is negative; so again, the delta neutral ratio can be calculated by dividing the absolute value of two deltas:

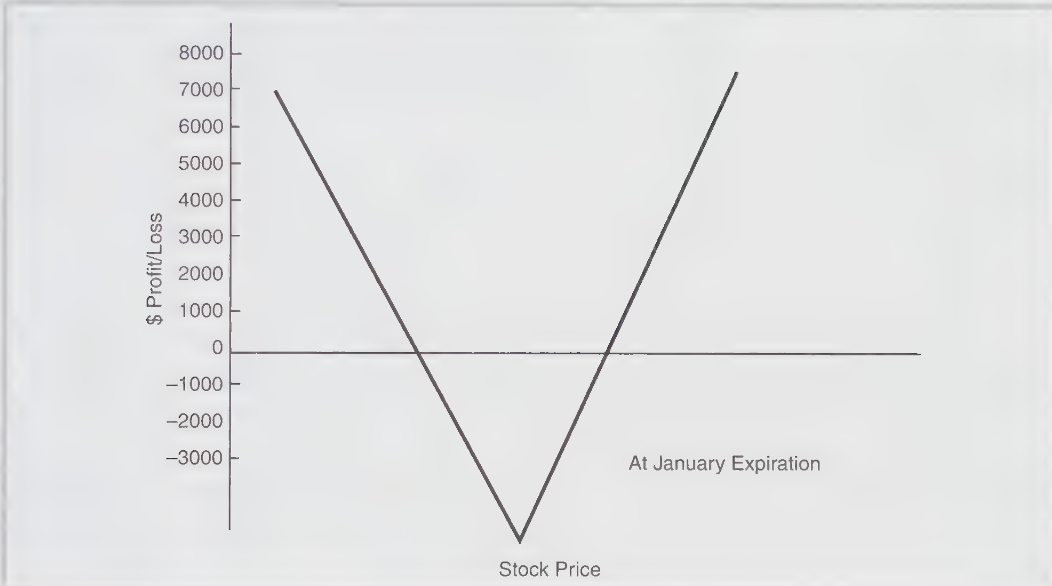
$$\text{Delta neutral straddle ratio} = 0.55/|-0.40| = 11\text{-to-}8$$

Thus, a delta neutral straddle position would consist of buying 8 January 50 calls and buying 11 February 50 puts. The straddle has no market exposure, at least over the short term. Note that the delta neutral straddle has a significantly different profit picture from the delta neutral ratio spread, but they are both neutral and are both based on the fact that the January 50 call is cheap. The straddle makes money if the stock moves a lot, while the other makes money if the stock moves only a little. (See Figure 40-9.)

Can these two vastly different profit pictures be depicting strategies in which the same thing is to be accomplished (that is, to capture the underpriced nature of the XYZ January 50 call)? Yes, but in order to decide which strategy is "best," the strategist would have to take other factors into consideration: the historical volatility of the underlying security, for example, or how much actual time remains until January expiration, as well as his own psychological attitude toward selling uncovered calls. A more precise definition of the other risks of these two positions can be obtained by looking at their position gammas.

Delta Neutral Is Not Entirely Neutral. In fact, delta neutral means that one is neutral *only with respect to small price changes in the underlying security.* A delta neutral position may have seriously unneutral characteristics when some of the other risk

FIGURE 40-9.
XYZ straddle buy.



measurements are considered. Consequently, one cannot blithely go around establishing delta neutral positions and ignoring them, for they may have significant market risk as certain factors change.

For example, it is obvious to the naked eye that the two positions described in the previous section—the ratio spread and the long straddle—are not alike at all, but both are delta neutral. If one incorporates the usage of some of the other risk measurements into his position, he will be able to quantify the differences between "neutral" strategies. The sale of a straddle will be used to examine how these various factors work.

Positions with naked options in them have negative position gamma. This means that as the underlying security moves, the position will acquire traits opposite to that movement: If the security rises, the position becomes short; if it falls, the position becomes long. This description generally fits any position with naked options, such as a ratio spread, a naked straddle, or a ratio write.

Example: XYZ is at 88. There are three months remaining until July expiration, and the volatility of XYZ is 30%. Suppose 100 July 90 straddles are sold for 10 points—the put and the call each selling for 5. Initially, this position is nearly delta neutral, as shown in Table 40-9. However, since both options are sold, each sale places negative gamma in the position.

The usefulness of calculating gamma is shown by this example. The initial position

TABLE 40-9.
Position delta and gamma of straddle sale. XYZ = 88.

Position	Option Delta	Position Delta	Option Gamma	Position Gamma
Sell 100 July 90 calls	0.505	–5,050	0.03	–300
Sell 100 July 90 puts	0.495	+4,950	0.03	–300
Total shares		– 100		–600

is NET short only 100 shares of XYZ, a very small delta. In fact, a person who is a trader of small amounts of stock might actually be induced into believing that he could sell these 100 straddles, because that is equivalent to being short merely 100 shares of the stock.

Calculating the gamma quickly dispels those notions. The gamma is large: 600 shares of negative gamma. Hence, if the stock moves only 2 points lower, this trader's straddle position can be expected to behave as if it were now long 1,100 shares (the original 100 shares short plus 1,200 that the gamma tells us we can expect to get long)! The position might look like this after the stock drops 2 points:

XYZ: 86

Position	Option Delta	Position Delta
Sold 100 July 90 calls	0.44	–4,400
Sold 100 July 90 puts	0.55	+5,500
		+1,100 shares

Hence, a 2-point drop in the stock means that the position is already acquiring a "long" look. Further drops will cause the position to become even "longer." This is certainly not a position—being short 100 straddles—for a small trader to be in, even though it might have erroneously appeared that way when one observed only the delta of the position. Paying attention to gamma more fully discloses the real risks.

In a similar manner, if the stock had *risen* 2 points to 90, the position would quickly have become delta short. In fact, one could expect it to be short 1,300 shares in that case: the original short 100 shares plus the 1,200 indicated by the negative gamma. A rise to 90, then, would make the position look like this:

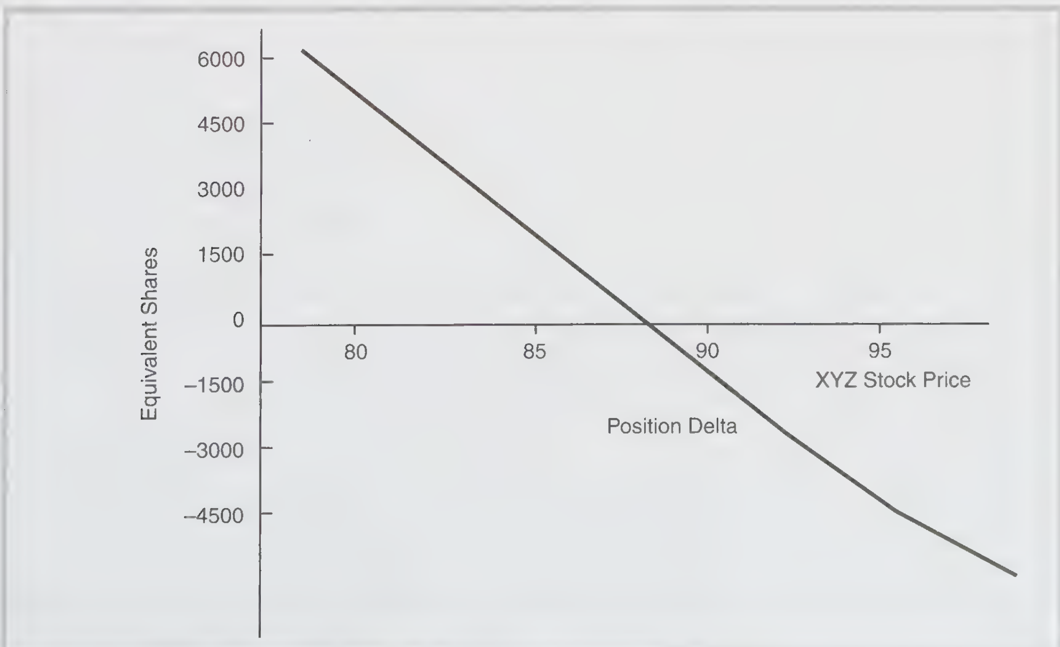
XYZ: 90

Position	Option Delta	Position Delta
Sold 100 July 90 calls	0.56	–5,600
Sold 100 July 90 puts	0.43	+4,300
		–1,300 shares

These examples demonstrate how quickly a large position, such as being short 100 straddles, can acquire a large delta as the stock moves even a small distance. Extrapolating the moves is not completely correct, because the gamma changes as the stock price changes, but it can give the trader some feel for how much his delta will change.

It is often useful to calculate this information in advance, to some point in the near future. Figure 40-10 depicts what the delta of this large short straddle position will be, two weeks after it was first sold. The points on the horizontal axis are stock prices. The quickness with which the neutrality of the position disappears is alarming. A small move up to 93—only one standard deviation—in two weeks makes the overall position short

FIGURE 40-10.
Projected delta, in 14 days.



the equivalent of about 3,300 shares of XYZ. Figure 40-10 really shows nothing more than the effect that gamma is having on the position, but it is presented in a form that may be preferable for some traders.

What this means is that the position is "fighting" the market: As the market goes up, this position becomes shorter and shorter. That can be an unpleasant situation, both from the point of view of creating unrealized losses as well as from a psychological viewpoint. *The position delta and gamma can be used to estimate the amount of unrealized loss that will occur.* Just how much can this position be expected to lose if there is a quick move in the underlying stock? The answer is quickly obtained from the delta and gamma: With the first point that XYZ moves, from 88 to 89, the position acts as if it is short 100 shares (the position delta), so it would lose \$100. With the next point that XYZ rises, from 89 to 90, the position will act as if it is short the original 100 shares (the position delta), plus another 600 shares (the position gamma). Hence, during that second point of movement by XYZ, the entire position will act as if it is short 700 shares, and therefore lose another \$700. Therefore, an immediate 2-point jump in XYZ will cause an unrealized loss of \$800 in the position. Summarizing:

Loss, first point of stock movement = position delta
Loss, second point of stock movement = position delta + gamma
Total loss for 2 points of stock movement
= 2 × position delta + position gamma

Using the example data:

Loss, XYZ moves from 88 to 89: −\$100 (the position delta)
Loss, XYZ moves from 89 to 90: −\$100 (delta) −\$600 (gamma)
: −\$700
Total loss, XYZ moves from 88 to 90: −\$100 × 2 −\$600 = −\$800

This can be verified by looking at the prices of the call and put after XYZ has jumped from 88 to 90. One could use a model to calculate expected prices if that happened. However, there is another way. Consider the following statements:

If the stock goes up by 1 point, the call will then have a price of:

$p_1 = p_0 + \text{delta}$
5.505 = 5.00 + 0.505 (if XYZ goes to 89 in the example)

If the stock goes up 2 points, the call will have an increase of the above amount plus a similar increase for the next point of stock movement. The delta for that second point of stock movement is the original delta plus the gamma, since gamma tells one how much his delta is going to change.

$$
\begin{aligned}
p_2 &= p_1 + \text{delta} + \text{gamma, or substituting from above} \\
p_2 &= (p_0 + \text{delta}) + \text{delta} + \text{gamma} \\
&= p_0 + 2 \times \text{delta} + \text{gamma} \\
6.04 &= 5.00 + 2 \times 0.505 + 0.03 \text{ (in the example if XYZ} = 90)
\end{aligned}
$$

By the same calculation, the put in the example will be priced at 4.04 if XYZ immediately jumps to 90:

$$4.04 = 5.00 - 2 \times 0.495 + 0.03$$

So, overall, the call will have increased by 1.04, but the put will only have decreased by 0.96. The unrealized loss would then be computed as –$10,400 for the 100 calls, offset by a gain of $9,600 on the sale of 100 puts, for a net unrealized loss of $800. This verifies the result obtained above using position delta and position gamma. Again, this confirms the logical fact that a quick stock movement will cause unrealized losses in a short straddle position.

Continuing on, let us look at some of the other factors affecting the sale of this straddle. The straddle seller has time working in his favor. After the position is established, there will not be as much decay in the first two-week period as there will be when expiration draws near. The exact amount of time decay to expect can be calculated from the theta of the position:

XYZ: 88

Position	Option Theta	Position Theta
Sold 100 July 90 calls	–0.03	+$300
Sold 100 July 90 puts	–0.03	+$300
		+$600

This is how the position looked with respect to time decay when it was first established (XYZ at 88 and three months remaining until expiration). The theta of the put and the call are essentially the same, and indicate that each option is losing about 3 cents of value each day. Note that the theta is expressed as a negative number, and since these options are sold, the *position theta* is a positive number. A positive position theta means time decay is working in your favor. One could expect to make $300 per day from the sale of the 100 calls. He could expect to make another $300 per day from the sale of the 100 puts. Thus, his overall position is generating a theoretical profit from time decay of $600 per day.

The fact that the sale of a straddle generates profits from time decay is not earth-shattering. That is a well-known fact. However, the *amount* of that time decay is quantified by using theta. Furthermore, it serves to show that this position, which is *delta* neutral, is *not* neutral with respect to the passage of time.

Finally, let us examine the position with respect to changes in volatility. This is done by calculating the position vega.

XYZ: 88

Position	Option Vega	Position Vega
Sold 100 July 90 calls	0.18	–$1,800
Sold 100 July 90 puts	0.18	–$1,800
		–$3,600

Again, this information is displayed at the time the position was established, three months to expiration, and with a volatility of 30% for XYZ. The vega is quite large. The fact that the call's vega is 0.18 means that the call price is expected to increase by 18 cents if the implied volatility of the option increases by one percentage point, from 30% to 31%. Since the position is short 100 calls, an increase of 18 cents in the price of the call would translate into a loss of $1,800. The put has a similar vega, so the overall position would lose $3,600 if the options trade with an increase in volatility of just one percentage point. Of course, the position would make $3,600 if the volatility decreased by one percentage point, to 29%.

This volatility risk, then, is the greatest risk in this short straddle position. As before, it is obvious that an increase in volatility is not good for a position with naked options in it. The use of vega quantifies this risk and shows how important it is to attempt to sell overpriced options when establishing such positions. One should not adhere to any one strategy all the time. For example, one should not always be selling naked puts. If the implied volatilities of these puts are below historical norms, such a strategy is much more likely to encounter the risk represented by the position vega. There have been several times in the recent past—mostly during market crashes—when the implied volatilities of both index and equity options have leaped tremendously. Those times were not kind to sellers of options. However, in almost every case, the implied volatility of index options was quite low before the crash occurred. Thus, any trader who was examining his vega risk would not have been inclined to sell naked options when they were historically "cheap."

In summary then, this "neutral" position is, in reality, much more complex when one considers all the other factors.

Position summary

Risk Factor	Comment
Position delta = –100	Neutral; no immediate exposure to small market movements; lose $100 for 1 point move in underlying.
Position gamma = –600	Fairly negative; position will react inversely to market movements, causing losses of $700 for second point of movement by underlying.
Position theta = +$600	Favorable; the passage of time works in the position's favor.
Position vega = –$3,600	Very negative; position is extremely subject to changes in implied volatility.

This straddle sale has only one thing guaranteed to work for it initially: time decay. (The risk factors will change as price, time, and volatility change.) Stock price movements will not be helpful, and there will always be stock price movements, so one can expect to feel the negative effect of those price changes. Volatility is the big unknown. If it decreases, the straddle seller will profit handsomely. Realistically, however, it can only decrease by a limited amount. If it increases, very bad things will happen to the profitability of the position. Even worse, if the implied volatility is increasing, there is a fairly likely chance that the underlying stock will be jumping around quite a bit as well. That isn't good either. *Thus, it is imperative that the straddle seller engage in the strategy only when there is a reasonable expectation that volatilities are high and can be expected to decrease.* If there is significant danger of the opposite occurring, the strategy should be avoided.

If volatility remains relatively stable, one can anticipate what effects the passage of time will have on the position. The delta will not change much, since the options are nearly at-the-money. However, the gamma will increase, indicating that nearer to expiration, short-term price movements will have more exaggerated effects on the unrealized profits of the position. The theta will grow even more, indicating that time will be an even better friend for the straddle writer. Shorter-term options tend to decay at a faster rate than do longer-term ones. Finally, the vega will decrease some as well, so that the effect of an increase in implied volatility alone will not be as damaging to the position when there is significantly less time remaining. So, the passage of time generally will improve most aspects of this naked straddle sale. However, that does not mitigate the current situation, nor does it imply that there will be no risk if a little time passes.

The type of analysis shown in the preceding examples gives a much more in-depth look than merely envisioning the straddle sale as being delta short 100 shares or looking at how the position will do at expiration. In the previous example, it is known that the straddle writer will profit if XYZ is between 80 and 100 in three months, at expiration. However, what might happen in the interim is another matter entirely. The delta, gamma, theta, and vega are useful for the purpose of defining how the position will behave or misbehave at the current point in time.

Refer back to the table of strategies at the beginning of this section. Notice that ratio writing or straddle selling (they are equivalent strategies) have the characteristics that have been described in detail: Delta is 0, and several other factors are negative. It has been shown how those negative factors translate into potential profits or losses. Observing other lines in the same table, note that covered writing and naked put selling (they are also equivalent, don't forget) have a description very similar to straddle selling: Delta is positive, and the other factors are negative. This is a worse situation than selling naked straddles, for it entails all the same risks, but in addition will suffer losses on immediate downward moves by the underlying stock. The point to be made here is that if one felt that straddle selling is not a particularly attractive strategy after he had observed these examples, he then should feel even less inclined to do covered writing, for it has all the same risk factors and isn't even delta neutral.

An example that was given in the chapter on futures options trading will be expanded as promised at this time. To review, one may often find volatility skewing in futures options, but it was noted that one should not normally buy an at-the-money call (the cheapest one) and sell a large quantity of out-of-the-money calls just because that looks like the biggest theoretical advantage. The following example was given. It will now be expanded to include the concept of gamma.

Example: Heavy volatility skewing exists in the prices of January soybean options: The out-of-the-money calls are much more expensive than the at-the-money calls.

The following data is known:

January soybeans: 583

Option	Price	Implied Volatility	Delta	Gamma
575 call	19.50	15%	0.55	.0100
675 call	2.25	23%	0.09	.0026

Using deltas, the following spread appears to be neutral:

Buy 1 January bean 575 call at 19.50	19.50 DB
Sell 6 January bean 675 calls at 2.25	13.50 CR
Net position:	6 Debit

At the time the original example was presented, it was demonstrated through the use of the profit picture that the ratio was too steep and problems could result in a large rally.

Now that one has the concept of gamma at his disposal, he can quantify what those problems are.

The position gamma of this spread is quite negative:

$$\text{Position gamma} = .01 - 6 \times .0026 = -0.0056$$

That is, for every 10 points that January soybeans rally, the position will become short about ½ of one futures contract. The maximum profit point, 675, is 92 points above the current price of 583. While beans would not normally rally 92 points in only a few days, it does demonstrate that this position could become very short if beans quickly rallied to the point of maximum profit potential. Rest assured there would be no profit if that happened.

Even a small rally of 20 cents (points) in soybeans—less than the daily limit—would begin to make this tiny spread noticeably short. If one had established the spread in some quantity, say buying 100 and selling 600, he could become seriously short very fast.

A neutral spreader would not use such a large ratio in this spread. Rather, he would neutralize the gamma and then attempt to deal with the resulting delta. The next section deals with ways to accomplish that.

CREATING MULTIFACETED NEUTRALITY

So what is the strategist to do? He can attempt to construct positions that are neutral with respect to the other factors if he perceives them as a risk. There is no reason why a position cannot be constructed as vega neutral rather than delta neutral, if he wants to eliminate the risk of volatility increases or decreases. Or, maybe he wants to eliminate the risk of stock price movements, in which case he would attempt to be gamma neutral as well as delta neutral.

This seems like a simple concept until one first attempts to establish a position that is neutral with respect to more than one risk variable. For example, if one is attempting to create a spread that is neutral with respect to both gamma and delta, he could attempt it in the following way:

Example: XYZ is 60. A spreader wants to establish a spread that is neutral with respect to both gamma and delta, using the following prices:

Option	Delta	Gamma
October 60 call	0.60	0.050
October 70 call	0.25	0.025

The secret to determining a spread that is neutral with respect to both risk measures is to neutralize gamma first, for delta can always be neutralized by taking an offsetting position in the underlying security, whether it be stock or futures. First, determine a *gamma* neutral spread by dividing the two gammas:

$$\text{Gamma neutral ratio} = 0.050/0.025 = 2\text{-to-}1$$

So, buying one October 60 and selling two October 70 calls would be a gamma neutral spread. Now, the position delta of that spread is computed:

Position	Delta	Position Delta
Long 1 October 60 call	0.60	+60 shares
Short 2 October 70 calls	0.25	–50 shares
Net position delta:		+10 shares

Hence, this gamma neutral ratio is making the position delta long by 10 shares of stock for each 1-by-2 spread that is established. For example, if one bought 100 October 60 calls and sold 200 October 70 calls, his position delta would be long 1,000 shares.

This position delta is easily neutralized by selling short 1,000 shares of the stock. The resulting position is both gamma neutral and delta neutral:

Position	Option Delta	Position Delta	Option Gamma	Position Gamma
Short 1,000 XYZ	1.00	–1,000	0	0
Long 100 October 60 calls	0.60	+6,000	0.050	+500
Short 200 October 70 calls	0.25	–5,000	0.025	–500
Net Position:		0		0

Hence, it is always a simple matter to create a position that is both gamma and delta neutral. In fact, it is just as simple to create a position that is neutral with respect to delta and any other risk measure, because all that is necessary is to create a neutral ratio of the other risk measure (gamma, vega, theta, etc.) and then eliminate the resulting position delta by using the underlying.

In theory, one could construct a position that was neutral with respect to all five risk measures (or six, if you really want to go overboard and include "gamma of the gamma" as well). Of course, there wouldn't be much profit potential in such a position, either. But such constructions are actually employed, or at least attempted, by traders such as market-makers who try to make their profits from the difference between the bid and offer of an option quote, and not from assuming market risk.

Still, the concept of being neutral with respect to more than one risk factor is a valid one. In fact, if a strategist can determine what he is really attempting to accomplish, he can often negate other factors and construct a position designed to accomplish exactly what he wants. Suppose that one thought the implied volatility of a certain set of options was too high. He could just sell straddles and attempt to capture that volatility. However, he is then exposed to movements by the underlying stock. He would be better served to construct a position with negative vega to reflect his expectation on volatility, but then also have the position be delta neutral and gamma neutral, so that there would be little risk to the position from market movements. This can normally be done quite easily. An example will demonstrate how.

Example: XYZ is 48. There are three months to expiration, and the volatility of XYZ and its options is 35%. The following information is also known:

XYZ: 48

Option	Price	Delta	Gamma	Vega
April 50 call	2.50	0.47	0.045	0.08
April 60 call	1.00	0.17	0.026	0.06

For whatever reasons—perhaps the historical volatility is much lower—the strategist decides that he wants to sell volatility. That is, he wants to have a negative position vega so that when the volatility decreases, he will make money. This can probably be accomplished by buying some April 50 calls and selling more April 60 calls. However, he does not want any risk of price movement, so some analysis must be done.

First, he should determine a *gamma* neutral spread. This is done in much the same manner as determining a delta neutral spread, except that gamma is used. Merely divide the two gammas to determine the neutral ratio to be used. In this case, assume that the April 50 call and the April 60 call are to be used:

$$\text{Gamma neutral ratio: } 0.045/0.026 = 1.73\text{-to-}1$$

Thus, a gamma neutral position would be created by buying 100 April 50's and selling 173 April 60's. Alternatively, buying 10 and selling 17 would be close to gamma neutral as well. The larger position will be used for the remainder of this example.

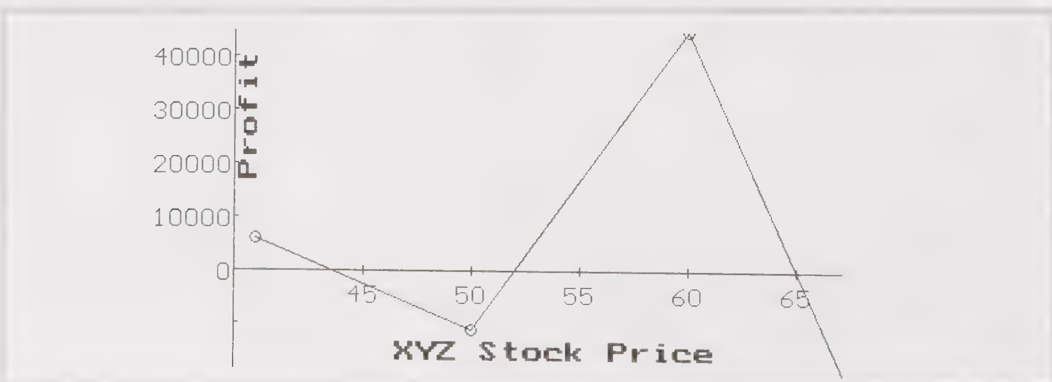
Now that this ratio has been chosen, what is the effect on delta and vega?

Position	Option Delta	Position Delta	Option Gamma	Position Gamma	Option Vega	Position Vega
Long 100 April 50	0.47	+4,700	0.045	+450	0.08	+$800
Short 173 April 60	0.17	–2,941	0.026	–450	0.06	–1,038
Total:		+1,759		0		–$238

The position delta is long 1,759 shares of XYZ. This can easily be "cured" by shorting 1,700 or 1,800 shares of XYZ to neutralize the delta. Consequently, the complete position, including the short 1,700 shares, would be neutral with respect to both delta and gamma, and would have the desired negative vega.

The actual profit picture at expiration is shown in Figure 40-11. Bear in mind, however, that the strategist would normally not intend to hold a position like this until

FIGURE 40-11.
Spread with negative vega; gamma and delta neutral.



expiration. He would close it out if his expectations on volatility decline were fulfilled (or proved false).

One other point should be made: The fact that gamma and delta are neutral to begin with does not mean that they will remain neutral indefinitely as the stock moves (or even as volatility changes). However, there will be little or no effect of stock price movements on the position in the short run.

In summary, then, one can always create a position that is neutral with respect to both gamma and delta by first choosing a ratio that makes the gamma zero, and then using a position in the underlying security to neutralize the delta that is created by the chosen ratio. This type of position would always involve two options and some stock. The resulting position will not necessarily be neutral with respect to the other risk factors.

THE MATHEMATICAL APPROACH

The strategist should be aware that the process of determining neutrality in several of the risk variables can be handled quite easily by a computer. All that is required is to solve a series of simultaneous equations.

In the preceding example, the resulting vega was negative: −$238. For each decline of 1 percentage point in volatility from the current level of 35%, one could expect to make $238. This result could have been reached by another method, as long as one were willing to spell out in advance the amount of vega risk he wants to accept. Then, he can also assume the gamma is zero and solve for the quantity of options to trade in the spread. The delta would be neutralized, as above, by using the common stock.

Example: Prices are the same as in the preceding example. XYZ is 48. There are three months to expiration, and the volatility of XYZ and its options is 35%. The following information is also the same:

Option	Price	Delta	Gamma	Vega
April 50 call	2.50	0.47	0.045	0.08
April 60 call	1.01	0.17	0.026	0.06

A spreader expects volatility to decline and is willing to set up a position whereby he will profit by $250 for each one percentage decrease in volatility. Moreover, he wants to be gamma and delta neutral. He knows that he can eventually neutralize any delta by using XYZ common stock, as in the previous example. How many options should be spread to achieve the desired result?

To answer the question, one must create two equations in two unknowns, x and y.

The unknowns represent the quantities of options to be bought and sold, respectively. The constants in the equations are taken from the table above.

The first equation represents gamma neutral:

$$0.045x + 0.026y = 0,$$

where

x is the number of April 50's in the spread and y is the number of April 60's. Note that the constants in the equation are the gammas of the two calls involved.

The second equation represents the desired vega risk of making 2.5 points, or $250, if the volatility decreases:

$$0.08x + 0.06y = -2.5,$$

where

x and y are the same quantities as in the first equation, and the constants in this equation are the gammas of the options. Furthermore, note that the vega risk is negative, since the spreader wants to profit if volatility decreases.

Solving the two equations in two unknowns by algebraic methods yields the following results:

Equations:

$$0.045x + 0.026y = 0$$
$$0.08x + 0.06y = -2.5$$

Solutions:

$$x = 104.80$$
$$y = -181.45$$

This means that one would buy 105 April 50 calls, since x being positive means that the options would be bought. He would also sell 181 April 60 calls (y is negative, which implies that the calls would be sold). This is nearly the same ratio determined in the previous example. The quantities are slightly higher, since the vega here is –$250 instead of the –$238 achieved in the previous example.

Finally, one would again determine the amount of stock to buy or sell to neutralize the delta by computing the position delta:

$$\text{Position delta} = 105 \times 0.47 - 181 \times 0.17 = 18.58$$

Thus 1,858 shares of XYZ would be shorted to neutralize the position.

Note: All the equations cannot be set equal to zero, or the solution will be all zeros. This is easily handled by setting at least one equation equal to a small, nonzero quantity, such as 0.1. *As long as at least one of the risk factors is nonzero, one can determine the neutral ratio for all other factors merely by solving these simultaneous equations.* There are plenty of low-cost computer programs that can solve simultaneous equations such as these.

This concept can be carried to greater lengths in order to determine the best spread to create in order to achieve the desired results. One might even try to use three different options, using the third option to neutralize delta, so that he wouldn't have to neutralize with stock. The third equation would use deltas as constants and would be set to equal zero, representing delta neutral. Solving this would require solving three equations in three unknowns, a simple matter for a computer.

As long as at least one of the risk factors is nonzero, one can determine the neutral ratio for all other factors merely by solving these simultaneous equations. Even more importantly, the computer can scan many combinations of options that produce a position that is both gamma and delta neutral and has a specific position vega (–$238, for example). One would then choose the "best" spread of the available possibilities by logical methods including, if possible, choosing one with positive theta, so time is working in his favor.

To summarize, one can neutralize all variables, or he can specify the risk that he wants to accept in any of them. Merely write the equations and solve them. It is best to use a computer to do this, but the fact that it can be done adds an entirely new, broad dimension to option spreading and risk-reducing strategies.

EVALUATING A POSITION USING THE RISK MEASURES

The previous sections have dealt with establishing a new position and determining its neutrality or lack thereof. However, the most important use of these risk measures is to predict how a position will perform into the future. At a minimum, a serious strategist should use a computer to print out a projection of the profits and losses and position risk at future expected prices. Moreover, this type of analysis should be done for several future times in order to give the strategist an idea of how the passage of time and the resultant larger movements by the underlying security would affect the position.

First, one would choose an appropriate time period—say, 7 days hence—for the first analysis. Then he should use the statistical projection of stock prices (see Chapter 28 on mathematical applications) to determine probable prices for the underlying security at that time. Obviously, this stock price projection needs to use volatility, and that is somewhat variable. But, for the purposes of such a projection, it is acceptable to use the current volatility. The results of as many as 9 stock prices might be displayed: every one-half standard deviation from –2 through +2 (–2.0, –1.5, –1.0, –0.5, 0, 0.5, 1.0, 1.5, 2.0).

Example: XYZ is at 60 and has a volatility of 35%. A distribution of stock prices 7 days into the future would be determined using the equation:

$$\text{Future Price} = \text{Current Price} \times e^{av\sqrt{t}}$$

where
a corresponds to the constants in the following table: (–2.0 . . . 2.0):

#Standard Deviations	Projected Stock Price
–2.0	54.46
–1.5	55.79
–1.0	57.16
–0.5	58.56
0	60.00
0.5	61.47
1.0	62.98
1.5	64.52
2.0	66.11

Again, refer to Chapter 28 on mathematical applications for a more in-depth discussion of this price determination equation.

Note that the formula used to project prices has time as one of its components. This means that as we look further out in time, the range of possible stock prices will expand—a necessary and logical component of this analysis. For example, if the prices were being determined 14 days into the future, the range of prices would be from 52.31 to 68.82. That is, XYZ has the same probability of being at 54.46 in 7 days that it has of being at 52.31 in 14 days. At expiration, some 90 days hence, the range would be quite a bit wider still. *Do not make the mistake of trying to evaluate the position at the same prices for each time period (7 days, 14 days, 1 month, expiration, etc.).* Such an analysis would be wrong.

Once the appropriate stock prices have been determined, the following quantities would be calculated for each stock price: profit or loss, position delta, position gamma, position theta, and position vega. (Position rho is generally a less important risk measure for stock and futures short-term options.) Armed with this information, the strategist can be prepared to face the future. An important item to note: A model will necessarily be used to make these projections. As was shown earlier, if there is a distortion in the current implied volatilities of the options involved in the position, *the strategist should use the current implieds as input to the model for future option price projections.* If he does not, the position may look overly attractive if expensive options are being sold or cheap ones are being bought. A truer profit picture is obtained by propagating the current implied volatility structure into the near future.

Using an example similar to the previous one—a ratio spread using short stock to make it delta neutral—the concepts will be described.

Initial Position. XYZ is at 60. The January 70 calls, which have three months until expiration, are expensive with respect to the January 60 calls. A strategist expects this discrepancy to disappear when the implied volatility of XYZ options decreases. He therefore established the following position, which is both gamma and delta neutral.

Position	Delta	Gamma	Theta	Vega
Long 100 January 60 calls	0.565	0.0723	–0.020	0.109
Short 240 January 70 calls	0.204	0.0298	–0.019	0.080
Short 800 XYZ				

The risk measures for the entire position are:

Position delta: –46 shares (virtually delta neutral)
Position gamma: +8 shares (gamma neutral)
Position theta: +$256
Position vega: –$830

Thus, the position is both gamma and delta neutral. Moreover, it has the attractive feature of making $256 per day because of the positive theta. Finally, as was the intention of the spreader, it will make money if the volatility of XYZ declines: $830 for each percentage point decrease in implied volatility. Two equations in two unknowns (gamma and vega) were solved to obtain the quantities to buy and sell. The resulting position delta was neutralized by selling 800 XYZ.

The following analyses will assume that the relative expensiveness of the April 70 calls persists. These are the calls that were sold in the position. If that overpricing should disappear, the spread would look more favorable, but there is no guarantee that they will cheapen—especially over a short time period such as one or two weeks.

How would the position look in 7 days at the stock prices determined above?

Stock Price	P&L	Delta	Gamma	Theta	Vega
54.46	1905	– 7.40	1.62	0.94	– 1.57
55.79	1077	– 4.90	2.07	1.18	– 1.96
57.16	606	– 1.97	2.13	1.53	– 2.90
58.56	528	0.74	1.65	2.00	– 4.62
60.00	771	2.38	0.56	2.63	– 7.22
61.47	1127	2.07	–1.01	3.38	–10.63
62.98	1252	– 0.87	–2.85	4.22	–14.56
64.52	702	– 6.73	–4.67	5.07	–18.61
66.11	–1019	–15.42	–6.21	5.85	–22.31

In a similar manner, the position would have the following characteristics after 14 days had passed:

Stock Price	P&L	Delta	Gamma	Theta	Vega
52.31	4221	– 9.10	0.69	0.55	– 0.98
54.14	2731	– 6.93	1.69	0.75	– 0.89
56.02	1782	– 2.87	2.51	1.06	– 1.21
57.98	1717	2.17	2.44	1.61	– 2.69
60.00	2577	5.85	1.00	2.51	– 6.00
62.09	3839	5.29	–1.63	3.73	– 11.05
64.26	4361	– 1.55	–4.61	5.09	– 16.90
66.50	2631	–14.80	–7.02	6.31	– 22.17
68.82	–2799	–32.83	–8.32	7.18	– 25.72

The same information will be presented graphically in Figure 40-13 so that those who prefer pictures instead of columns of numbers can follow the discussions easily.

First, the profitability of the spread can be examined. This profit picture assumes that the volatility of XYZ remains unchanged. Note that in 7 days, there is a small profit if the stock remains unchanged. This is to be expected, since theta was positive, and therefore time is working in favor of this spread. Likewise, in 14 days, there is an even bigger profit if XYZ remains relatively unchanged—again due to the positive theta. Overall, there is an expected profit of $800 in 7 days, or $2,600 in 14 days, from this position. This indicates that it is an attractive situation statistically, but, of course, it does not mean that one cannot lose money.

Continuing to look at the profit picture, the downside is favorable to the spread since the short stock in the position would contribute to ever larger profits in the case that XYZ tumbles dramatically (see Figure 40-12). The upside is where problems could develop. In 7 days, the position breaks even at about 65 on the upside; in 14 days, it breaks even at about 67.50.

The reader may be asking, "Why is there such a dramatic risk to the upside? I thought the position was delta neutral and gamma neutral." True, the position was originally neutral with respect to both those variables. That neutrality explains the flatness of the profit curves about the current stock price of 60. However, once the stock has moved 1.50 standard deviations to the upside, the neutrality begins to disappear. To see this, let us look at Figures 40-13 and 40-14 that show both the position delta and position gamma 7 days and 14 days after the spread was established. Again, these are the same numbers listed in the previous tables.

First, look at the position delta in 7 days (Figure 40-13). Note that the position remains relatively delta neutral with XYZ between 57 and 63. This is because the gamma was initially neutral. However, the position begins to get quite delta short if XYZ rises

FIGURE 40-12.
XYZ ratio spread, gamma and delta neutral.

FIGURE 40-13.
XYZ ratio spread, position delta.

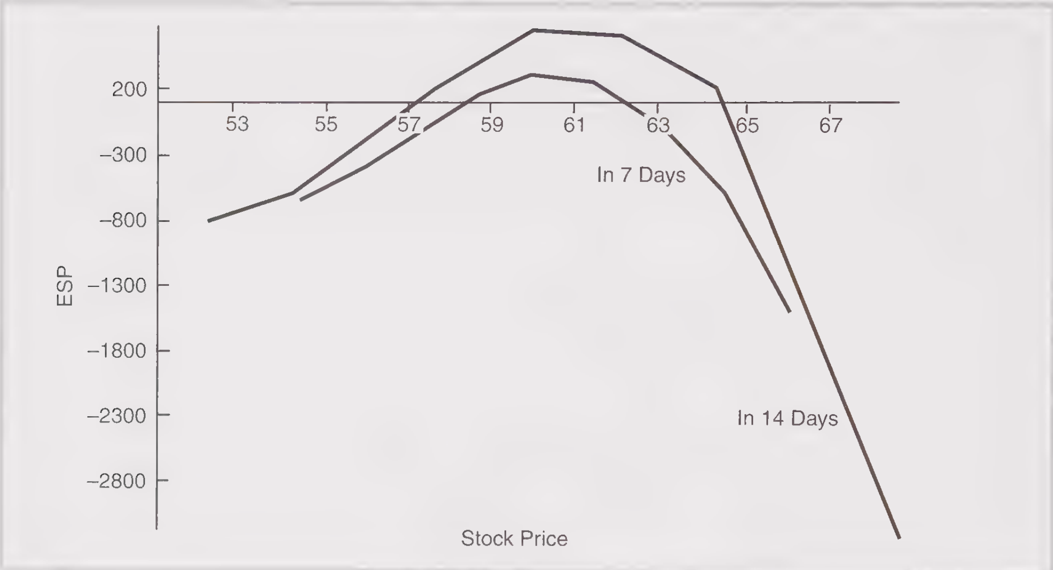


FIGURE 40-14.
XYZ ratio spread, position gamma.

above 63 or falls below 57 in 7 days. What is happening to gamma while this is going on? Since we just observed that the delta eventually changes, that has to mean that the position is acquiring some gamma.

Figure 40-14 depicts the fact that gamma is not very stable, considering that it started at nearly zero. If XYZ falls, gamma increases a little, reflecting the fact that the position will get somewhat shorter as XYZ falls. But since there are only calls coupled with short stock in this position, there is no risk to the downside. Positive gamma, even a small positive gamma like this one, is beneficial to stock movement.

The upside is another matter entirely. The gamma begins to become seriously negative above a stock price of 63 in 7 days. Recall that negative gamma means that one's position is about to react poorly to price changes in the market—the position will soon be "fighting the market." As the stock goes even higher, the gamma becomes even more negative. These observations apply to stock price movements in either 7 days or 14 days; in fact, the effect on gamma does not seem to be particularly dependent on time in this example, since the two lines on Figure 40-15 are very close to each other.

The above information depicts in detailed form the fact that this position will not behave well if the stock rises too far in too short a time. However, stable stock prices will produce profits, as will falling prices. These are not earth-shattering conclusions since, by simple observation, one can see that there are extra short calls plus some short stock in the position. However, the point of calculating this information in advance is to be able to anticipate where to make adjustments and how much to adjust.

Follow-Up Action. How should the strategist use this information? A simplistic approach is to adjust the delta as it becomes non-neutral. This won't do anything for gamma, however, and may therefore not necessarily be the best approach. If one were to adjust only the delta, he would do it in the following manner: The chart of delta (Figure 40-13) shows that the position will be approximately delta short 800 shares if XYZ rises to 64.50 in a week. One simple plan would be to cover the 800 shares of XYZ that are short if the stock rises to 64.50. Covering the 800 shares would return the position to delta neutral at that time. Note that if the stock rises at a slower pace, the point at which the strategist would cover the 800 shares moves higher. For example, the delta in 14 days (again in Figure 40-13) shows that XYZ would have to be at about 65.50 for the position to be delta short 800 shares. Hence, if it took two weeks for XYZ to begin rising, one could wait until 65.50 before covering the 800 shares and returning the position to delta neutral.

In either case, the purchase of the 800 shares does not take care of the negative gamma that is creeping into the position as the stock rises. *The only way to counter negative gamma is to buy options, not stock.* To return a position to neutrality with respect to more than one risk variable requires one to approach the problem as he did when the position was established: Neutralize the gamma first, and then use stock to adjust the delta. Note the difference between this approach and the one described in the previous paragraph. Here, we are trying to adjust gamma first, and will get to delta later.

In order to add some positive gamma, one might want to buy back (cover) some of the January 70 calls that are currently short. Suppose that the decision is made to cover when XYZ reaches 65.50 in 14 days. From the graph above, one can see that the position would be approximately gamma short 700 shares at the time. Suppose that the gamma of the January 70 calls is 0.07. Then, one would have to cover 100 January 70 calls to add 700 shares of positive gamma to the position, returning it to gamma neutral. This purchase would, of course, make the position delta long, so some stock would have to be sold short as well in order to make the position delta neutral once again.

Thus, the procedure for follow-up action is somewhat similar to that for establishing the position: First, neutralize the gamma and then eliminate the resulting delta by using the common stock. The resulting profit graph will not be shown for this follow-up adjustment, since the process could go on and on. However, a few observations are pertinent. First, *the purchase of calls to reduce the negative gamma hurts the original thesis of the position*—to have negative vega and positive theta, if possible. Buying calls will add vega to and subtract theta from the position, which is not desirable. However, it is more desirable than letting losses build up in the position as the stock continues to run to the upside. Second, *one might choose to remove the position if it is profitable*. This might happen if the volatility did decrease as expected. Then, when the stock rallies, producing negative gamma, one might actually have a profit, because his assumption concerning volatility had been right. If he does not see much further potential gains from decreasing volatility, he might use the point at which negative gamma starts to build up as the exit point from his position. Third, *one might choose to accept the acquired gamma risk*. Rather than jeopardize his initial thesis, one may just want to adjust the delta and let the gamma build up. This is no longer a neutral strategy, but one may have reasons for approaching the position this way. At least he has calculated the risk and is aware of it. If he chooses to accept it rather than eliminate it, that is his decision.

Finally, it is obvious that *the process is dynamic*. As factors change (stock price, volatility, time), the position itself changes and the strategist is presented with new choices. There is no absolutely correct adjustment. The process is more of an art than a science at times. Moreover, the strategist should continue to recalculate these profit pictures and risk measures as the stock moves and time passes, or if there is a change in the securities involved in the position. There is one absolute truism and that is that *the serious strategist should be aware of the risk his position has with respect to at least the four basic measures of delta, gamma, theta, and vega*. To be ignorant of the risk is to be delinquent in the management of the position.

TRADING GAMMA FROM THE LONG SIDE

The strategist who is selling overpriced options and hedging that purchase with other options or stock will often have a position similar to the one described earlier. Large stock movements—at least in one direction—will typically be a problem for such positions. The opposite of this strategy would be to have a position that is long gamma. That is, the position does better if the stock moves quickly in one direction. While this seems pleasing to the psyche, these types of positions have their own brand of risk.

The simplest position with long gamma is a long straddle, or a backspread (reverse ratio spread). Another way to construct a position with long gamma is to invert a calendar spread—to buy the near-term option and to sell a longer-term one. Since a near-term option has a higher gamma than a longer-term one with the same strike, such a position has long gamma. In fact, traders who expect violent action in a stock often construct such a position for the very reason that the public will come in behind them, bid up the short-term calls (increasing their implied volatility), and make the spread more profitable for the trader.

Unfortunately, all of these positions often involve being long just about everything else, including theta and vega as well. This means that time is working against the position, and that swings in implied volatility can be helpful or harmful as well. Can one construct a position that is long gamma, but is not so subject to the other variables? Of course he can, but what would it look like? The answer, as one might suspect, is not an ironclad one.

For the following examples, assume these prices exist:

XYZ: 60

Option	Price	Delta	Gamma	Theta	Vega
March 60 call	3.25	0.54	0.0510	0.033	0.089
June 60 call	5.50	0.57	0.0306	0.021	0.147

Example: Suppose that a strategist wants to create a position that is *gamma long, but is neutral with respect to both delta and vega.* He thinks the stock will move, but is not sure of the price direction, and does not want to have any risk with respect to quick changes in volatility. In order to quantify the statement that he "wants to be gamma long," let us assume that he wants to be gamma long 1,000 shares or 10 contracts.

It is known that delta can always be neutralized last, so let us concentrate on the other two variables first. The two equations below are used to determine the quantities to buy in order to make gamma long and vega neutral:

$$0.0510x + 0.0306y = 10 \text{ (gamma, expressed in \# of contracts)}$$

$$0.089x + 0.147y = 0 \text{ (vega)}$$

The solution to these equations is:

$$x = 308,\ y = -186$$

Thus, one would buy 308 March 60 calls and would sell 186 June 60 calls. This is the reverse calendar spread that was discussed: Near-term calls are bought and longer-term calls are sold.

Finally, the delta must be neutralized. To do this, calculate the position delta using the quantities just determined:

$$\text{Position delta} = 0.54 \times 308 - 0.57 \times 186 = 60.30$$

So, the position is long 60 contracts, or 6,000 shares. It can be made delta neutral by selling short 6,000 shares of XYZ.

The overall position would look like this:

Position	Delta	Gamma	Vega
Short 6,000 XYZ	1.00	0	0
Long 308 March 60 calls	0.54	0.0510	0.089
Short 186 June 60 calls	0.57	0.0306	0.147

Its risk measurements are:
Position delta: long 30 shares (neutral)
Position vega: $7 (neutral)
Position gamma: long 1,001 shares

This position then satisfies the initial objectives of wanting to be gamma long 1,000 shares, but delta and vega neutral.

Finally, note that theta = −$625. The position will lose $625 per day from time decay.

The strategist must go further than this analysis, especially if one is dealing with positions that are not simple constructions. He should calculate a profit picture as well as look at how the risk measures behave as time passes and the stock price changes.

Figure 40-15 (see Tables 40-10, 40-11, and 40-12) shows the profit potential in 7 days, in 14 days, and at March expiration. Figure 40-16 shows the position vega at the 7- and 14-day time intervals. Before discussing these items, the data will be presented in tabular form at three different times: in 7 days, in 14 days, and at March expiration.

FIGURE 40-15.
Trading long gamma, profit picture.

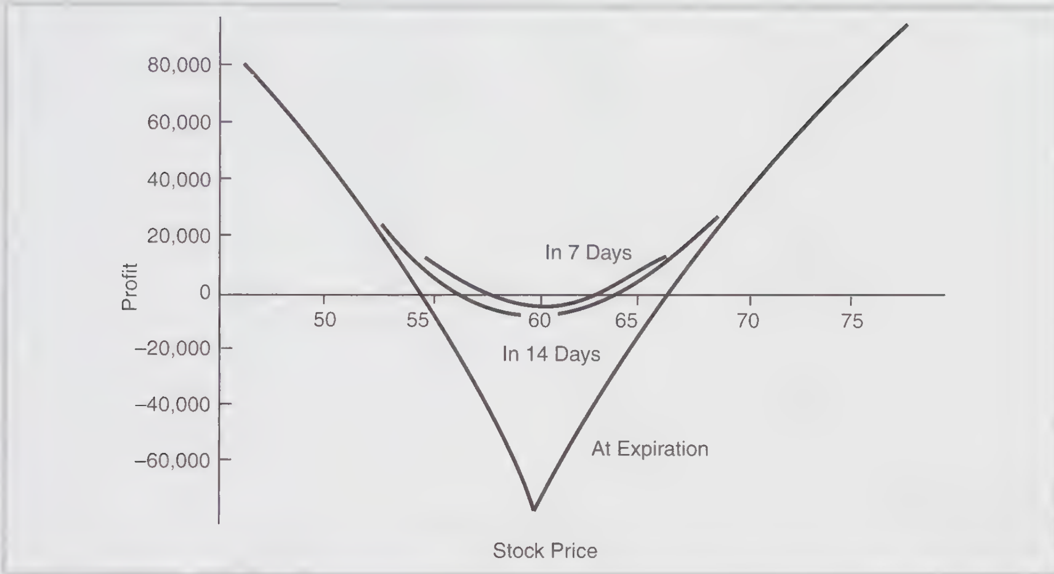


TABLE 40-10.
Risk measures of long gamma position in 7 days.

Stock Price	P&L	Delta	Gamma	Theta	Vega
54.46	12259	–58.72	8.28	4.15	–5.74
55.79	5202	–46.60	9.78	5.20	–4.18
57.16	– 224	–32.45	10.80	6.09	–2.85
58.56	– 3670	–16.91	11.25	6.73	–1.94
60.00	– 4975	– 0.80	11.08	7.04	–1.63
61.47	– 3901	15.01	10.32	6.98	–1.96
62.98	– 507	29.69	9.09	6.57	–2.89
64.52	5105	42.56	7.54	5.87	–4.29
66.11	12717	53.17	5.86	4.97	–5.96

The data in Table 40-10 depict the position in 7 days.

Table 40-11 represents the results in 14 days.

Finally, the position as it looks at March expiration should be known as well (see Table 40-12).

TABLE 40-11.
Risk measures of long gamma position in 14 days.

Stock Price	P&L	Delta	Gamma	Theta	Vega
52.31	24945	–79.34	4.75	2.10	– 9.91
54.14	11445	–67.68	8.00	3.91	– 7.87
56.02	277	–49.79	10.79	5.76	– 5.56
57.98	– 7263	–26.87	12.42	7.21	– 3.73
60.00	– 10141	– 1.44	12.47	7.88	– 3.04
62.09	– 7784	23.32	10.99	7.60	– 3.78
64.26	– 347	44.47	8.45	6.47	– 5.71
66.50	11491	60.12	5.55	4.82	– 8.20
68.82	26672	69.81	2.92	3.09	–10.48

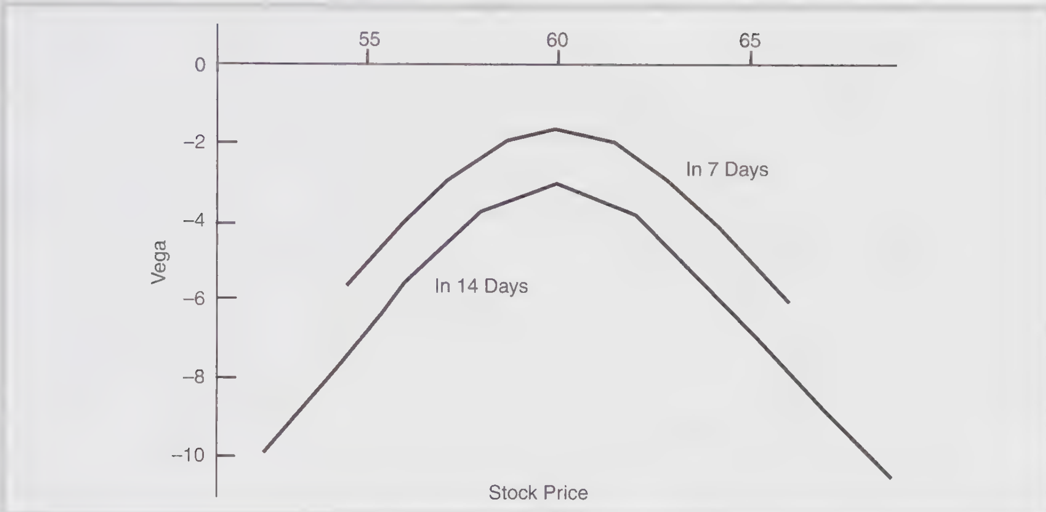
TABLE 40-12.
Risk measures of long gamma position at March expiration.

Stock Price	P&L	Delta	Gamma	Theta	Vega
46.19	81327	– 75.69	–3.65	–1.32	– 6.88
49.31	55628	– 89.84	–5.39	–2.25	– 11.43
52.64	22378	–110.50	–6.89	–3.33	–16.50
56.20	–21523	–136.65	–7.62	–4.28	–20.67
60.00	–78907	144.68	–7.29	–4.79	–22.49
64.06	–25946	117.44	–6.03	–4.70	–21.26
68.39	19787	95.03	–4.31	–4.10	– 17.44
73.01	59732	79.05	–2.67	–3.24	–12.43
77.95	96062	69.19	–1.43	–2.41	– 7.69

In each case, note that the stock prices are calculated in accordance with the statistical formula shown in the last section. The more time that passes, the further it is possible for the stock to roam from the current price.

The profit picture (Figure 40-15) shows that this position looks much like a long straddle would: It makes large, symmetric profits if the stock goes either way up or way down. Moreover, the losses if the stock remains relatively unchanged can be large. These losses tend to mount right away, becoming significant even in 14 days. Hence, if one enters this type of position, he had better get the desired stock movement quickly, or be prepared to cut his losses and exit the position.

FIGURE 40-16.
Trading long gamma, position vega.



The most startling thing to note about the entire position is the devastating effect of time on the position. The profit picture shows that large losses will result if the stock movement that is expected does not materialize. These losses are completely due to time decay. Theta is negative in the initial position ($625 of losses per day), and remains negative—and surprisingly constant—until March expiration (when the long calls expire). Time also affects vega. Notice how the vega begins to get negative right away and keeps getting much more negative as time passes. Simply, it can be seen that as time passes, the position becomes *vulnerable to increases in implied volatility.*

This relationship between time and volatility might not be readily apparent to the strategist unless he takes the time to calculate these sorts of tables or figures. In fact, one may be somewhat confounded by this observation. What is happening is that as time passes, the options that are owned are less explosive if volatility increases, but the options that were sold have a lot of time remaining, and are therefore apt to increase violently if volatility spurts upward.

Figures 40-17 and 40-18 provide less enlightening information about delta and gamma. Since gamma was positive to start with, the delta increases dramatically as the stock rises, and decreases just as fast if the stock falls (Figure 40-18). This is standard behavior for positions with long gamma; a long straddle would look very similar.

Notice that gamma remains positive throughout (Figure 40-17), although it falls to smaller levels if the stock moves toward the end of the pricing ranges used in the analyses. Again, this is standard action for a long straddle.

FIGURE 40-17.
Trading long gamma, position gamma.

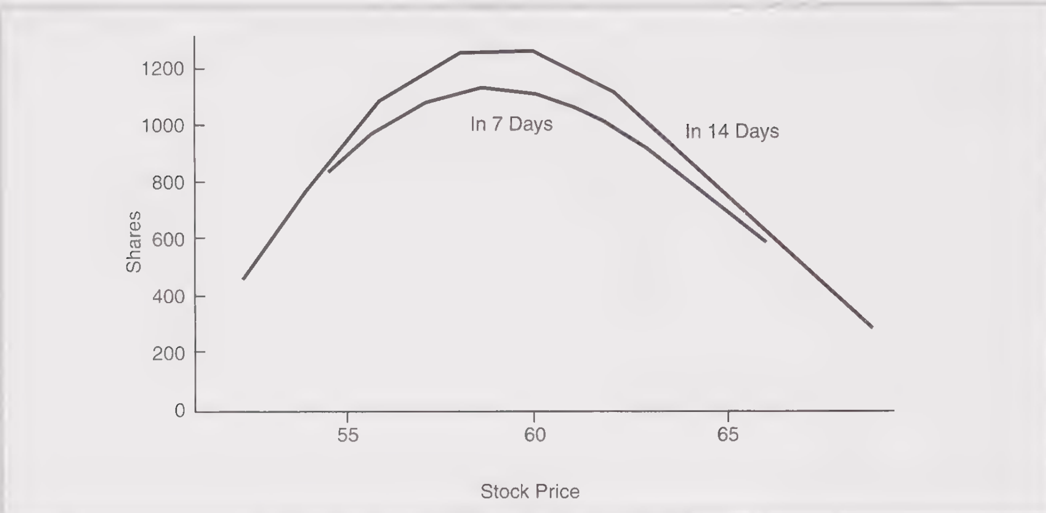
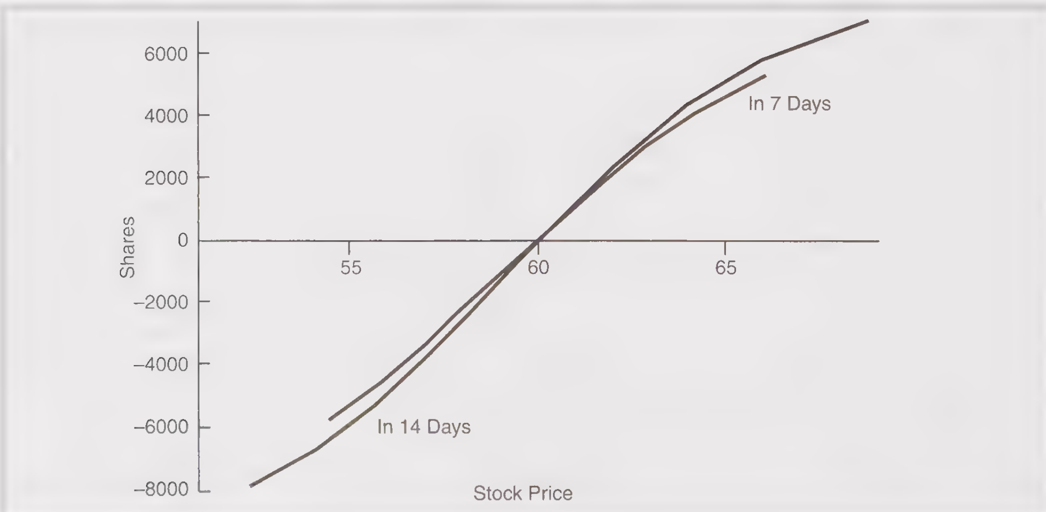


FIGURE 40-18.
Trading long gamma, position delta.



So, is this a good position? That is a difficult question to answer unless one knows what is going to happen to the underlying stock. Statistically, this type of position has a negative expected return and would generally produce losses over the long run. However, in situations in which the near-term options are destined to get overheated—perhaps because of a takeover rumor or just a leak of material information about a company—many sophisticated traders establish this type of position to take advantage of the expected explosion in stock price.

Other Variations. Without going into as much detail, it is possible to compare the above position with similar ones. The purpose in doing so is to illustrate how a change in the strategist's initial requirements would alter the established position. In the preceding position, the strategist wanted to be gamma long, but neutral with respect to delta and volatility. Suppose he not only expects price movement (meaning he wants positive gamma), but also expects an increase in volatility. If that were the case, he would want positive vega as well. Suppose he quantifies that desire by deciding that he wants to make $1,000 for every one percentage increase in volatility. The simultaneous equations would then be:

$$0.0501x + 0.0306y = 10 \text{ (gamma)}$$
$$0.089x + 0.147y = 10 \text{ (vega)}$$

The solution to these equations is:

$$x = 243,\ y = -80$$

Furthermore, 8,500 shares would have to be sold short in order to make the position delta neutral. The resulting position would then be:

Short 8,500 XYZ	Delta: neutral
Long 243 March 60 calls	Gamma: long 1,000 shares
Short 80 June 60 calls	Vega: long $1,000
	Theta: long $630

Recall that the position discussed in the last section was vega neutral and was:

Short 6,000 XYZ	Delta: neutral
Long 308 March 60 calls	Gamma: long 1,000 shares
Short 186 June 60 calls	Vega: neutral
	Theta: long $625

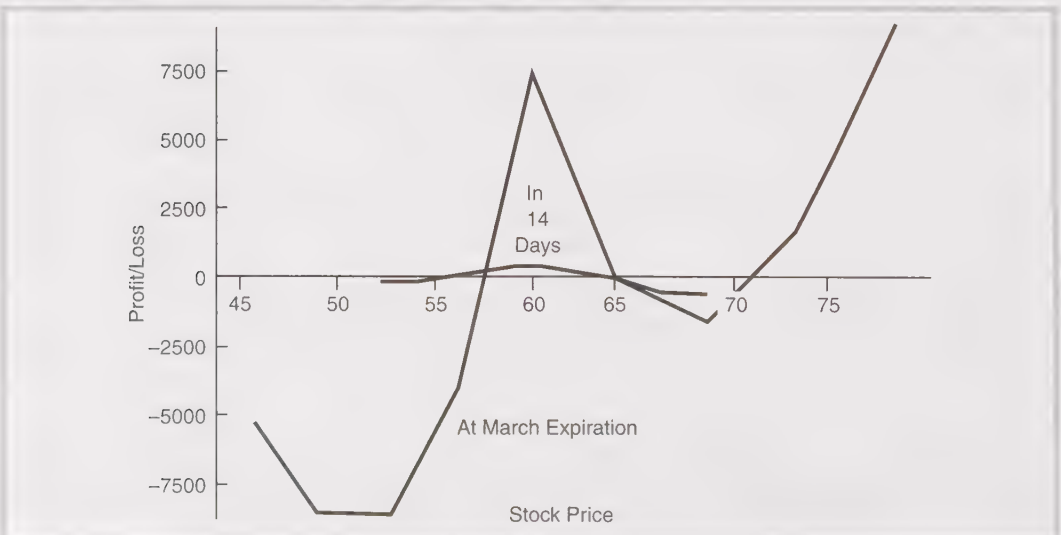
Notice that in the new position, there are over three times as many long March 60 calls as there are short June 60 calls. This is a much larger ratio than in the vega neutral position, in which about 1.6 calls were bought for each one sold. This even greater preponderance of near-term calls that are purchased means the newer position has an even larger exposure to time decay than did the previous one. That is, in order to acquire the positive vega, one is forced to take on even more risk with respect to time decay. For that reason, this is a less desirable position than the first one; it seems overly risky to want to be both long gamma and long volatility.

This does not necessarily mean that one would never want to be long volatility. In fact, if one expected volatility to increase, he might want to establish a position that was delta neutral and gamma neutral, but had positive vega. Again, using the same prices as in the previous examples, the following position would satisfy these criteria:

Short 2,600 XYZ	Delta: neutral
Short 64 March 60 calls	Gamma: neutral
Long 106 June 60 calls	Vega: long $1,000
	Theta: long $11

This position has a more conventional form. It is a calendar spread, except that more long calls are purchased. Moreover, the theta of this position is only $11—it will only lose $11 per day to time decay. At first glance it might seem like the best of the three choices. Unfortunately, when one draws the profit graph (Figure 40-19), he finds that this position has significant downside risk: The short stock cannot compensate for the large quantity of

FIGURE 40-19.
Trading long gamma, "conventional" calendar.



June 60 calls. Still, the position does make money on the upside, and will also make money if volatility increases. If the near-term March calls were overpriced with respect to the June calls at the time the position was established, it would make it even more desirable.

To summarize, defining the risks one wants to take or avoid specifies the construction of the eventual position. The strategist should examine the potential risks and rewards, especially the profit picture. If the potential risks are not desirable, the strategist should rethink his requirements and try again. Thus, in the example presented, the strategist felt that he initially wanted to be long gamma, but it involved too much risk of time decay. A second attempt was made, introducing positive volatility into the situation, but that didn't seem to help much. Finally, a third analysis was generated involving only long volatility and not long gamma. The resulting position has little time risk, but has risk if the stock drops in price. It is probably the best of the three. The strategist arrives at this conclusion through a logical process of analysis.

ADVANCED MATHEMATICAL CONCEPTS

The remainder of this chapter is a short adjunct to Chapter 28 on mathematical applications. It is quite technical. Those who desire to understand the basic concepts behind the risk measures and perhaps to utilize them in more advanced ways will be interested in what follows.

CALCULATING THE "GREEKS"

It is known that the equation for delta is a direct by-product of the Black–Scholes model calculation:

$$\Delta = \mathrm{N}(\mathrm{d}1)$$

Each of the risk measures can be derived mathematically by taking the partial derivative of the model. However, there is a shortcut approximation that works just as well. For example, the formula for gamma is as follows:

$$x = \ln\left[\frac{p}{s \times (1+r)^t}\right] \Big/ v\sqrt{t} + \frac{v\sqrt{t}}{2}$$

$$\Gamma = \frac{e^{(-x^2/2)}}{pv\sqrt{2\pi t}}$$

There is a simpler, yet correct, way to arrive at the gamma. The delta is the partial derivative of the Black–Scholes model with respect to stock price—that is, it is the amount by which the option's price changes for a change in stock price. The gamma is the change in delta for the same change in stock price. Thus, one can approximate the gamma by the following steps:

1. Calculate the delta with p = Current stock price.
2. Set p = p + 1 and recalculate the delta.
3. Gamma = delta from step 1 – delta from step 2.

The same procedure can be used for the other "greeks":

Vega:
1. Calculate the option price with a particular volatility.
2. Calculate another option price with volatility increased by 1%.
3. Vega = difference of the prices in steps 1 and 2.

Theta:
1. Calculate the option price with the current time to expiration.
2. Calculate the option price with 1 day less time remaining to expiration.
3. Theta = difference of the prices in steps 1 and 2.

Rho:
1. Calculate the option price with the current risk-free interest rate.
2. Calculate the option price with the rate increased by 1%.
3. Rho = difference of the prices in steps 1 and 2.

THE GAMMA OF THE GAMMA

The discussion of this concept was deferred from earlier sections because it is somewhat difficult to grasp. It is included now for those who may wish to use it at some time. Those readers who are not interested in such matters may skip to the next section.

Recall that this is the sixth risk measurement of an option position. *The gamma of the gamma is the amount by which the gamma will change when the stock price changes.*

Recall that in the earlier discussion of gamma, it was noted that gamma changes. This example is based on the same example used earlier.

Example: With XYZ at 49, assume the January 50 call has a delta of 0.50 and a gamma of 0.05. If XYZ moves up 1 point to 50, the delta of the call will increase by the amount of the gamma: It will increase from 0.50 to 0.55. Simplistically, if XYZ moves up another point to 51, the delta will increase by another 0.05, to 0.60.

Obviously, the delta cannot keep increasing by 0.05 each time XYZ gains another point in price, for it will eventually exceed 1.00 by that calculation, and it is known that the delta has a maximum of 1.00. Thus, it is obvious that the gamma changes.

In reality, the gamma decreases as the stock moves away from the strike. Thus, with XYZ at 51, the gamma might only be 0.04. Therefore, if XYZ moved up to 52, the call's delta would only increase by 0.04, to 0.64. Hence, the gamma of the gamma is –0.01, since the gamma decreased from .05 to .04 when the stock rose by one point.

As XYZ moves higher and higher, the gamma will get smaller and smaller. Eventually, with XYZ in the low 60's, the delta will be nearly 1.00 and the gamma nearly 0.00.

This change in the *gamma* as the stock moves is called the *gamma of the gamma*. It is probably referred to by other names, but since its use is limited to only the most sophisticated traders, there is no standard name. Generally, one would use this measure on his entire portfolio to gauge how quickly the portfolio would be responding to the position gamma.

Example: With XYZ at 31.75 as in some of the previous examples, the following risk measures exist:

Position	Option Delta	Option Gamma	Option Gamma/Gamma	Position Gamma/Gamma
Short 4,500 XYZ	1.00	0.00	0.0000	0
Short 100 XYZ April 25 calls	0.89	0.01	–0.0015	–15
Long 50 XYZ April 30 calls	0.76	0.03	–0.0006	– 3
Long 139 XYZ July 30 calls	0.74	0.02	–0.0003	– 4
		Total Gamma of Gamma:		–22

Recall that, in the same example used to describe gamma, the position was delta long 686 shares and had a positive gamma of 328 shares. Furthermore, we now see that the gamma itself is going to decrease as the stock moves up (it is negative) or will increase as the stock moves down. In fact, it is expected to increase or decrease by 22 shares for each point XYZ moves.

So, if XYZ moves up by 1 point, the following should happen:

a. Delta increases from 686 to 1,014, increasing by the amount of the gamma.
b. Gamma decreases from 328 to 306, indicating that a further upward move by XYZ will result in a smaller increase in delta.

One can build a general picture of how the gamma of the gamma changes over different situations—in- or out-of-the-money, or with more or less time remaining until expiration. The following table of two index calls, the January 350 with one month of life remaining and the December 350 with eleven months of life remaining, shows the delta, gamma, and gamma of the gamma for various stock prices.

Index Price	January 350 call			December 350 call		
	Delta	Gamma	Gamma/Gamma	Delta	Gamma	Gamma/Gamma
310	.0006	.0001	.0000	.3203	.0083	.0000
320	.0087	.0020	.0004	.3971	.0082	.0000
330	.0618	.0100	.0013	.4787	.0080	–.0000
340	.2333	.0744	.0013	.5626	.0078	–.0001
350	.5241	.0309	–.0003	.6360	.0073	–.0001
360	.7957	.0215	–.0014	.6984	.0067	–.0001
370	.9420	.0086	–.0010	.7653	.0060	–.0001
380	.9892	.0021	–.0003	.8213	.0052	–.0001

Several conclusions can be drawn, not all of which are obvious at first glance. First of all, the gamma of the gamma for long-term options is very small. This should be expected, since the delta of a long-term option changes very slowly. The next fact can best be observed while looking at the shorter-term January 350 table. The gamma of the gamma is near zero for deeply out-of-the-money options. But, as the option comes closer to being in-the-money, the gamma of the gamma becomes a positive number, reaching its maximum while the option is still out-of-the-money. By the time the option is at-the-money, the gamma of the gamma has turned negative. It then remains negative, reaching its most negative point when slightly in-the-money. From there on, as the option goes even deeper into-the-money, the gamma of the gamma remains negative but gets closer and closer to zero, eventually reaching (minus) zero when the option is very far in-the-money.

Can one possibly reason this risk measurement out without making severe mathematical calculations? Well, possibly. Note that the delta of an option starts as a small number when the option is out-of-the-money. It then increases, slowly at first, then more quickly, until it is just below 0.60 for an at-the-money option. From there on, it will continue to increase, but much more slowly as the option becomes in-the-money. This movement of the delta can be observed by looking at gamma: It is the change in the delta, so it starts slowly, increases as the stock nears the strike, and then begins to decrease as the option is in-the-money, always remaining a positive number, since delta can only change in the positive direction as the stock rises. Finally, the gamma of the gamma is the change in the gamma, so it in turn starts as a positive number as gamma grows larger; but then when gamma starts tapering off, this is reflected as a negative gamma of the gamma.

In general, the gamma of the gamma is used by sophisticated traders on large option positions where it is not obvious what is going to happen to the gamma as the stock changes in price. Traders often have some feel for their delta. They may even have some feel for how that delta is going to change as the stock moves (i.e., they have a feel for gamma). However, sophisticated traders know that even positions that start out with zero delta and zero gamma may eventually acquire some delta. The gamma of the gamma tells the trader how much and how soon that eventual delta will be acquired.

MEASURING THE DIFFERENCE OF IMPLIED VOLATILITIES

Recall that when the topic of implied volatility was discussed, it was shown that if one could identify situations in which the various options on the same underlying security had substantially different implied volatilities, then there might be an attractive neutral spread available. The strategist might ask how he is to determine if the discrepancies between the individual options are significantly large to warrant attention. Furthermore, is there a quick way (using a computer, of course) to determine this?

A logical way to approach this is to look at each individual implied volatility and compute the standard deviation of these numbers. This standard deviation can be converted to a percentage by dividing it by the overall implied volatility of the stock. This percentage, if it is large enough, alerts the strategist that there may be opportunities to spread the options of this underlying security against each other. An example should clarify this procedure.

Example: XYZ is trading at 50, and the following options exist with the indicated implied volatilities. We can calculate a standard deviation of these implieds, called implied deviation, via the formula:

Implied deviation = sqrt (sum of differences from mean)^2/(# options –1)

XYZ: 50

Option	Implied Volatility	Difference from Average
October 45 call	21%	–9.44
November 45 call	21%	–9.44
January 45 call	23%	–7.44
October 50 call	32%	+1.56
November 50 call	30%	–0.44
January 50 call	28%	–2.44
October 55 call	40%	+9.56
November 55 call	37%	+6.56
January 55 call	34%	+3.56

$$
\begin{aligned}
\text{Average: } 30.44\% \\
\text{Sum of (difference from avg)}^2 &= 389.26 \\
\text{Implied deviation} &= \text{sqrt (sum of diff)}^2/(\text{\# options} - 1) \\
&= \text{sqrt } (389.26/8) \\
&= 6.98
\end{aligned}
$$

This figure represents the raw standard deviation of the implied volatilities. To convert it into a useful number for comparisons, one must divide it by the average implied volatility.

$$
\begin{aligned}
\text{Percent deviation} &= \frac{\text{Implied deviation}}{\text{Average implied}} \\
&= 6.98/30.44 \\
&= 23\%
\end{aligned}
$$

This "percent deviation" number is usually significant if it is larger than 15%. That is, if the various options have implied volatilities that are different enough from each other to produce a result of 15% or greater in the above calculation, then the strategist should take a look at establishing neutral spreads in that security or futures contract.

The concept presented here can be refined further by using a weighted average of the implieds (taking into consideration such factors as volume and distance from the striking price) rather than just using the raw average. That task is left to the reader.

Recall that a computer can perform a large number of Black–Scholes calculations in a short period of time. Thus, the computer can calculate each option's implied volatility and then perform the "percent deviation" calculation even faster. The strategist who is interested in establishing this type of neutral spread would only have to scan down the list of percent deviations to find candidates for spreading. On a given day, the list is usually quite short—perhaps 20 stocks and 10 futures contracts will qualify.

SUMMARY

In today's highly competitive and volatile option markets, neutral traders must be extremely aware of their risks. That risk is not just risk at expiration, but also the current risk in the market. Furthermore, they should have an idea of how the risk will increase or decrease as the underlying stock or futures contract moves up and down in price. Moreover, the passage of time or the volatility that the options are being assigned in the marketplace—

the implied volatility—are important considerations. Even changes in short-term interest rates can be of interest, especially if longer-term options (LEAPS) are involved.

Once the strategist understands these concepts, he can use them to select new positions, to adjust existing ones, and to formulate specific strategies to take advantage of them. He can select a specific criteria that he wants to exploit—selling high volatility, for example—and use the other measures to construct a position that has little risk with respect to any of the other variables. Furthermore, the market-maker or specialist, who does not want to acquire any market risk if he can help it, will use these techniques to attempt to neutralize all of the current risk, if possible.

CHAPTER 41

Volatility Derivatives

At the beginning of listed option trading in 1973, when a "new" stock was added to the list of those with options, only call options were listed. Eventually, in 1976, puts were listed on a few stocks. At that time, option industry officials envisioned that all stocks with listed options would have both puts and calls (visionary at the time!). Of course, we know that today any stock that is added to the list of those with options immediately has puts and calls listed at all available striking prices.

Eventually, in 1983, listed index options came into being, and their popularity has been immense. However, options traders were still missing an important tool to effectively hedge a portfolio of stocks and other instruments; there was no direct way to address volatility. Sure, there are *strategies* with puts and calls designed to profit from—and perhaps, in a general sense, hedge—volatility, but they are clumsy at best, for they have many other components contributing to their risk-reward characteristics, other than mere volatility.

Many sophisticated option traders and trading desks designed and tracked volatility measures since the beginning of listed option trading, but in 1993, the CBOE formally published the Volatility Index, VIX—the first, and still the foremost, index of volatility in existence.

But the mere *publication* of VIX was just something traders could observe; they could not trade it. In fact, the calculation of VIX was changed in 2003, and shortly thereafter (2004) listed futures on VIX were introduced. The CBOE created its own futures exchange, the CBOE Futures Exchange (CFE) for this purpose. Futures were listed on both realized volatility (variance futures) and on implied volatility (VIX futures). Variance futures have not proven to be very popular with the populace who trades listed derivatives, but VIX futures have.

It took some trips back and forth to the drawing board, but eventually listed *options* on VIX were introduced in 2006. This has been one of the most successful new products ever introduced in listed options, and its popularity continues to grow among both speculators and hedgers looking to protect stock portfolios.

These options and futures—for the first time—allowed listed option traders to address volatility directly (over-the-counter institutional traders have had the ability for some time to trade both realized and implied volatility).

In this section of the book, we are going to take an in-depth look at listed volatility derivatives—from their definition, to their uses in speculation and strategy, and finally at their use for portfolio protection.

HISTORICAL AND IMPLIED VOLATILITY

Historical volatility measures how fast an entity (a stock, for example) has been moving around in the past. Implied volatility, on the other hand, is the option markets' estimate of how volatile the underlying is going to be during the life of the option. It is a forward-looking measure.

In Chapter 28, "Mathematical Applications," we described how volatility is calculated—both historical and implied. Recall that historical volatility is the standard deviation of daily *percentage* price changes in the stock, index, futures contract, or other entity you are monitoring. Variance is volatility squared. Historical volatility is a backward-looking measure because it uses past prices in its calculation.

Generally, actual volatility declines in bull markets and increases in bear markets. One reason is that, in bull markets, stocks tend to advance almost every day. But in bear markets, declines are often punctuated with sharp, short-lived rallies, and so the standard deviation of the daily price changes is much greater. In fact, novice investors and certain members of the media interchange the terms volatility and price decline. They might say "the market is volatile," when what they mean is "the market is down." This is incorrect, of course.

The general statement regarding volatility and price movement is not true in all markets, however. For example, in the tech stock bull market of 1995–2000, volatility generally increased even as prices were rising, for large gains in tech stocks were often punctuated with isolated, but significant, days of selling. As a general rule, on a daily basis, volatility moves opposite to the direction of the underlying entity about 75% of the time—certainly a significant amount of the time, but not *all* of the time.

Implied volatility, however, is strictly a component of option pricing, and is a forward-looking measure. It is the volatility that one would have to use in a theoretical model (such as the Black–Scholes model) in order for the model's estimate of "fair value" to be equal to the current market price of the option. There is not a specific formula for calculating implied volatility; rather, it is an iterative process.

As has been shown in many other places in this book, implied volatility is a very major determinant of what strategies are best used in certain situations. In general, high implied volatility means options are expensive and low implied volatility means they are cheap. But that is too general of a statement, for we have no real way of knowing what is "high" or "low," except by looking at past measures of volatility. When options were first listed, and the Black–Scholes model was introduced, many mathematically based traders (including this author) thought it would be a simple matter to determine if options were cheap or expensive, and buy or sell them accordingly. What was not realized initially was that there is no such thing as "fair value." It completely depends on your volatility estimates and how they relate to the eventual volatility of the underlying entity.

It is often the case that options seem to be trading with a volatility that is "too high," but it is usually justified. There may be an *event* on the horizon that will have significant bearing on a gap in the stock price—such as an FDA hearing, or an earnings report, or a takeover rumor. Even a sharp drop in the price of the underlying may cause implied volatility to rise, for traders fear further price drops and thus pay higher prices for puts.

CALCULATION OF VIX

The original CBOE Volatility Index calculation was released in 1993, with backdated data to 1986. The actual formula was designed by Dr. James Whaley, of Duke University. It used four series of OEX options, centered about the current OEX price—one strike above the OEX price, one below, in each of the first two expiration months. The implied volatilities of these options were weighted to come up with one number—the VIX.

At the time (1993), OEX options were still the most liquid and most popular index options. However, as time passed, S&P 500 options (SPX) began to take over that role, especially due to their popularity with large, institutional traders. Furthermore, option traders had known, since the Crash of '87, that deeply out-of-the-money puts on the indices were far more expensive—in terms of implied volatility—than at-the-money options were. Simultaneously, deeply out-of-the-money call options were less expensive than at-the-money options. Eventually, there was some demand for a new volatility calculation that would take these things into account.

So, in 2003, the CBOE revamped the calculation of VIX. The "old" VIX remains—its symbol was merely changed to VXO. The "new" VIX was based on SPX options, and incorporated all of the strikes trading in the first two expiration months. Actually, not *all* of the strikes are included, but nearly all are—all the ones with both bid and offer prices for the options. In the vernacular, it is said that the "new" VIX is based on the "strips" of options expiring in the first two months. The actual formula, which is complicated, can be found on the CBOE website, along with other papers on the subject.

Both the old and new VIX are 30-day volatility measures. As you will see later in this section, that is very important, for longer-term derivatives, expiring many months in the future will not track VIX well, for this very reason. What this 30-day estimate means, in mathematical terms, is that the two strips of SPX options that are used in the VIX calculation have a different weighting each day. As time passes from one month to the next, the strip of SPX options in the "near" month gets less weight and the strip in the "far" month gets more.

The VIX calculation is versatile. It can be applied to any set of options where continuous markets (bids and offers) are being made in the two strips of options in the two front-months. As a result, a VIX-like calculation of volatility can be made for nearly every listed stock, index, or futures contract.

In order to trade VIX options on any entity, it is first necessary to create a volatility, or VIX index, for that product. Regular listed puts and calls trade on the underlying stock (index or future), but VIX options can't trade on the stock price; rather, they must trade on a VIX index created from the puts and calls on that stock. So, first a VIX-like index is created; then, options can trade on it. As an example, SPX had listed puts and calls for years, then those options were used to calculate the original VIX for several months, and finally VIX futures and options were created, based on the VIX index.

Originally, VIX was the term and symbol for the CBOE Volatility Index. But the term has—in everyday usage—evolved more to describe the *process* of calculating volatility. As an example, consider Xerox. Originally it was the name of a company (and still is), but eventually the word Xerox evolved to mean "to copy" or even a "copying machine," no matter who manufactured it. This appears to be what is happening to VIX. Xerox actually tried a lawsuit to stop the generic use of its name, but was unsuccessful in that attempt.

In 2010 and 2011, the CBOE introduced VIX calculations on gold, crude oil, and the Euro (foreign currency). These used the options of the popular ETFs GLD, USO, and FXE, respectively. Later, VIX calculations were being broadcast on more ETFs and on certain individual stocks as well. Even the futures exchanges entered the fray, introducing a VIX calculation on gold and crude oil, based on the listed *futures* options that trade.

Since then, VIX calculations are being broadcast by the CBOE on a number of other ETFs and some individual stocks—which, at this time, include Apple (AAPL), Amazon (AMZN), Goldman Sachs (GS), Google (GOOG), and IBM (IBM), and the following ETFs: Emerging Markets (EEM), China (FXI), Brazil (EWZ), Gold Miners (GDX), Silver (SLV), and Energy (XLE). There are individual symbols for these volatility (VIX) calculations on each of these stocks and ETFs.

This seems very similar to 1976, when puts were introduced. At the time, it seemed hard to envision that every stock with listed options would have both puts and calls, but eventually that became the norm. We may now be on the verge of a future where every entity with listed options has puts, calls, and VIX options. Clearly, we are early in the process, but it is certainly possible.

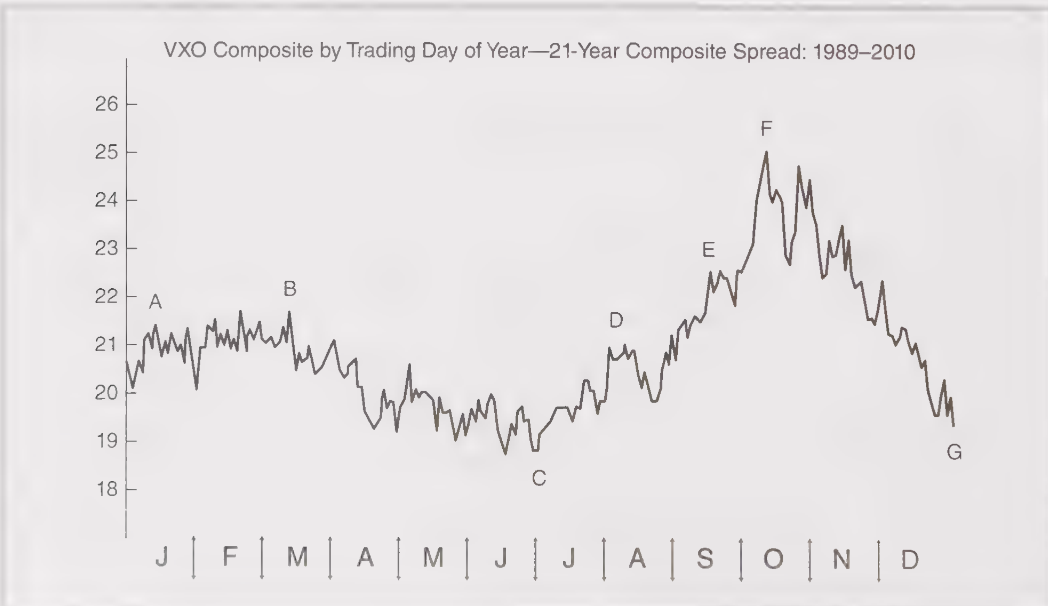
It will become necessary, if it isn't already, to *qualify* which VIX one is talking about. For years, VIX meant the calculation based on the SPX options. But it really is likely to be called "SPX VIX" as time progresses, to differentiate it from "Gold VIX," "Apple VIX," and so forth.

There is an annual seasonality of volatility that can sometimes be useful to traders. It is important to understand the general path that volatility takes during the course of a year. There may be variations in any individual year, but most years conform to the general pattern in some form or another.

Figure 41-1 shows the composite of the "old VIX" (VXO) for the 22-year period from 1989 through 2010. That is, the average VXO on the first day of each of the 22 years was plotted (it's about 20.75). Then the second day and third day, etc. VXO was used because it has a longer backdated historical data set. VIX and VXO move in tandem, so the conclusions below apply to VIX as well.

The pattern in Figure 41-1 is thus a 22-year *average* VXO for each trading day of the year. Volatility seems to rise slightly in January and then peaks in March. From there it falls during the spring into the yearly low, very near the first of July. Then a major increase

FIGURE 41-1.
Seasonality of volatility.



in volatility takes place, throughout the latter part of the summer (contrary to conventional wisdom that holds that August is a nonvolatile month), increasing rapidly through September and into October.

Of course, the stock market often falls sharply in September and October, thus creating the rise in volatility that is seen in Figure 41-1. About the time of this peak, the "average" trader might think that he has finally figured out what is going on with volatility—it is increasing. And even though he missed buying it during the summer he decides to buy it in October, figuring that even more volatile times lie ahead. Such is the lot of the individual investor, who is a contrarian indicator. But instead of rallying further, volatility begins to decrease during the fall of the year, retreating so dramatically that, by the end of the year, it is nearly back to the July lows!

This pattern doesn't hold for every year, of course. But in some years that seemingly don't fit the pattern, there is a distinct similarity. Consider 2010, for example. That was the year of the "flash crash" in May, followed by a sharp market decline. Therefore, VIX spiked from its yearly low in April to its yearly high in May. From there it generally declined throughout the rest of the year. In other words, the graph in Figure 41-1 was sort of "squashed" to the left for 2010. That happened in a few other years as well.

This seasonal data is not necessarily information that you would use to set up a specific strategy, but it does make clear that "buying" volatility in the late spring or early summer is a plausible approach, while selling it in the fall might also be useful.

LISTED VOLATILITY FUTURES

In 2004, the CBOE created its futures exchange—the CFE—with only two products in mind: listed futures on historical and implied volatility. Implied volatility futures—or VIX futures, as they are commonly known—have proven to be the far more popular product.

Futures were discussed in Chapter 34. If you are not at all familiar with futures, you may want to review that chapter, although the following information should suffice for understanding VIX futures. Do not skip this section if you are planning on trading *any* derivative volatility products. Even if you think that you might have no interest in trading VIX futures—only options on VIX—you must understand the futures on VIX in order to understand the options on VIX. Therefore this section is required reading.

A futures contract has an expiration date but no striking price. That is one major distinction between futures and options. Another is that futures trade with very high leverage, so that one does *not* have limited risk when trading a futures contract. On the contrary, his initial margin requirement may be wiped out by a fairly small, adverse move (say 10%) in the price of the futures contract.

VIX futures are quoted in price terms, much like VIX. For example, if VIX itself is trading near 20, then the various futures will be trading at prices slightly above 20, most likely. A VIX futures contract is worth $1,000 for every one point move it makes. So if one buys the July VIX futures contract at 21 and sells it at 22, he makes $1,000 less commissions.

The margin required by the futures broker can vary, depending on the price of the futures and on general market volatility. The exchanges are always allowed to raise margin prices to curb speculation if they so see fit. At this time, the exchange minimum margin for trading one VIX futures contract is $4,000. We will discuss spread margins later. Thus, the VIX futures contract has tremendous leverage, as do most futures contracts. A four-point move in the contract could double your money or wipe out your initial margin equity.

VIX FUTURES EXPIRATION DATE

VIX futures are listed for several months—at least the next seven contiguous months going forward from the current date. Each futures contract has an expiration date. At first glance, VIX expiration dates seem rather arcane, but there is actually a physical reason for the way these expiration dates are determined, as is the case with many futures expiration dates on all kinds of commodities and financial products.

The expiration of VIX futures in any given month is 30 days prior to the SPX option expiration in the *next* month. This is always a Wednesday. It may sometimes be the Wednesday *before* "regular" option expiration (which takes place on the third Friday of the month), or the Wednesday after. Those are the only two possibilities.

Example: July SPX options expire on Friday the 19th (the normal third Friday of the month). *June* VIX futures will thus expire 30 calendar days prior. That means back up 19 days in July, and 11 in June. Since June has 30 days in all, backing up 11 days from the end of the month puts the expiration date as Wednesday, June 19.

Why this 30-day "look-back"? Why not just have VIX futures expire on the third Friday, like all other stock and index options? Let's digress for a moment and discuss liquidity. No derivatives product will be liquid—or successful—without the ability to arbitrage it. For example, market-makers in puts and calls can hedge off equivalent positions by positioning stock against the options. This is what the regulators in October 2008 didn't realize when they wanted to ban short selling. Without the ability to sell short the underlying, option market-makers would be reluctant to take on long calls and/or short puts. That ban was quickly lifted for option market-makers (which effectively removed that ban for everyone because everyone else could buy *puts* and let the market-makers short stock to hedge the puts that the market-makers sold).

This 30-day look-back is necessary for market-makers to be able to hedge their futures positions. At first, designers of the VIX derivatives were having a hard time deciding how they could make the product hedgeable. Then they hit upon this idea. Recall that the VIX calculation requires the weighting of the two strips of SPX options, and that weighting changes each day. A market-maker in the futures, who takes down a big position in futures and wishes to hedge it with SPX options, would, in pure theory, have to establish positions in all of the SPX options in the two monthly strips, and then change his quantities in those two strips of options each day, as long as he held the arbitrage in place. This is preposterous, of course, and figuring out how to allow market-makers to effectively hedge large futures positions was what delayed the initial introduction of the product for some time.

Eventually, an ingenious solution was conceived. What if, on expiration day only, the VIX calculation for expiration futures only involved *one* strip of options—the one that expires 30 days hence? Then market-makers could take down a big position in futures, perhaps simultaneously hedging it with the options in *one* strip of SPX options, and hold the position in place without having to change SPX options quantities daily. This solved the problem, for the most part.

The actual expiration of the VIX futures takes place on the Wednesday morning of expiration, and a VIX calculation is done, using just the SPX options that are trading with an expiration of 30 days hence. There are rules governing exactly what price to use for the SPX options—an average of the bid and offer, or the last sale—that can be found on the CBOE website.

Once this "expiration-day-only" VIX computation is made, the VIX futures expire and settle for cash at that price.

Example: Continuing with the above example, on expiration day, Wednesday, June 19, the June VIX futures do not actually trade. Rather, when the July SPX options are opened for trading that morning, the first posted market or trade in each pertinent option in the whole strip is used in a VIX-like calculation (according to the regular VIX formula), and a "settlement VIX" is determined. This VIX settlement price is disseminated by the CBOE under the symbol VRO (quoted as an index). Thus, June futures are marked to that price and expire. They are removed from each customer's account at that price, and the resulting gain or loss is booked as realized. This is similar to the process whereby other cash-based financial futures—such as S&P 500 futures—expire.

Suppose that an account had bought June VIX futures at a price of 23.25 and held them until expiration. Furthermore, suppose that at expiration, VRO is determined to be 20.84. Then a realized loss of 2.41 points, or $2,410 dollars, would be booked into his account, and the futures position would be removed from the account. In reality, the futures would have been marked to market daily in his account, so that $2,410 loss would have been accumulating for some time.

There have been some accusations of chicanery surrounding VIX expiration—rumors that traders of the SPX options are putting up prints in out-of-the-money options at illogical prices in order to make VRO jump at expiration. These generally fall into the category of urban legend—more fiction than fact. There are procedures in place to throw out truly outlying SPX option prices at expiration.

Nevertheless, there have been many instances of VRO jumping by a great deal from the previous night's closing VIX price. These are generally due to overnight market movements, which cause SPX to gap open the next day. As a result, it is probably good practice to close out your VIX derivative positions prior to expiration rather than merely holding them all the way into expiration.

FUTURES COMPARED TO VIX: PREMIUMS OR DISCOUNTS

If a futures contract is trading at a higher price than VIX, it is said to be trading at a premium. Conversely, if a futures contract is trading at a lower price than VIX, it is said to be trading at a discount. In other words—as is the case with S&P futures and many other futures contracts—the terms premium or discount refer to the relationship of the futures with respect to VIX, not the other way around. That is, one would *not* say "VIX is trading at a discount to the futures contract," but would instead say "the futures contract is trading at a premium to VIX."

It is useful to traders of volatility to pay attention to the premium of the futures. But it is insufficient to merely use the premium on the front-month futures contract. When time gets very short for the front-month futures, it is not as important as the next futures contract is. Therefore, it is useful to compute a *blended* premium, using the two front-month futures contracts.

Since VIX is a 30-day weighted average of the two front-month strips of options, and this refers to *calendar* days, we can use the two front-month futures prices to directly compute this blended premium.

Example: The following prices exist on the first day after the June VIX futures have become the front-month contract. Assume that there are 4 weeks (i.e., 20 trading days) between June and July VIX derivatives expiration.

VIX: 23.05
June VIX futures: 25.00
July VIX futures: 27.50
Therefore the premiums are:

June premium: $25.00 - 23.05 = 1.95$
July premium: $27.50 - 23.05 = 4.45$

Since there are 20 days between the two expirations, and there are 19 days remaining until July expiration, June has a weight of 95% and July 5%. So the *blended* premium would be:

$$0.95 \times \text{June} + 0.05 \times \text{July} =$$
$$0.95 \times 1.95 + 0.05 \times 4.45 = 2.125$$

The next day, the weights would be 0.90 and 0.10, and on the next .85 and .15, and so forth. When there are *five* weeks between the two VIX expirations, that means there are 25 trading days between them, so the weights could change by 0.04 each day (i.e., on the first day the weights would be 0.96 and 0.04, then 0.92 and 0.08 the next day, and so forth).

If one computes the VIX premium in *this* manner, there will always be a smooth transition right through VIX expiration. Otherwise, if one used only the front-month futures contract, there would be a jump or gap each time the futures expired, for the front-month future has very little premium as it is about to expire—no matter *how* much traders are paying for the next month.

THE TERM STRUCTURE

When one talks about the collective status of the premiums on all the futures contracts, he is said to be referring to the term structure of the futures. It is usually the case that the various futures contracts—extending out seven months in time, or more—trade in a pattern. One pattern that is fairly common is to see larger and larger premiums on the futures, as one looks farther out in time.

Example: This is an example of a positive-sloping term structure:

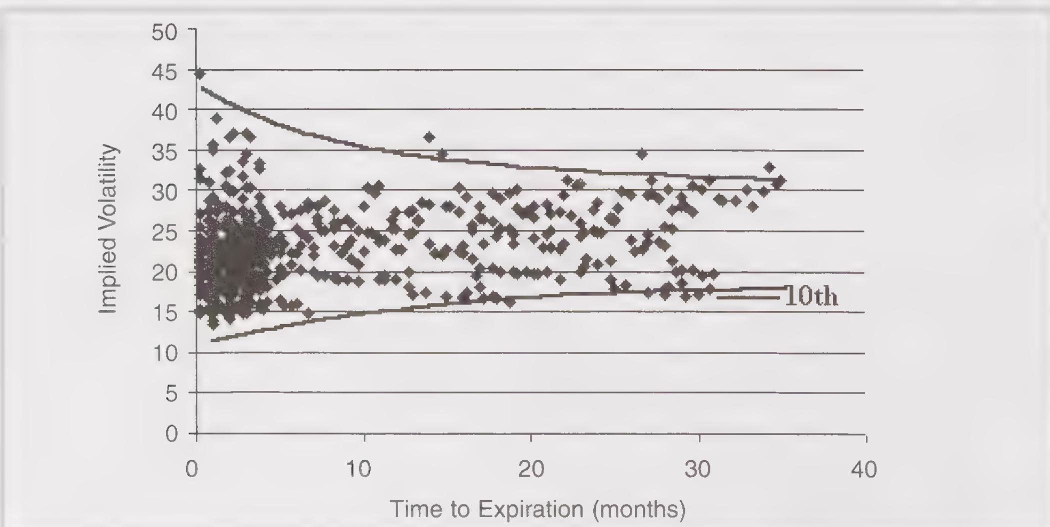
VIX:	17.86
June VIX futures:	19.00
July VIX futures:	19.60
August VIX futures:	20.55
September VIX futures:	21.75
October VIX futures:	22.60
November VIX futures:	23.15
December VIX futures:	23.35
January VIX futures:	24.25

See how each futures contract is trading at a slightly higher price than its predecessor? That is a positive slope to the term structure. We will be discussing and referring to the term structure quite a bit in this chapter, but it really means that traders are paying a higher implied volatility for SPX options expiring farther out in time than they are willing to pay for short-term SPX options.

We have addressed this concept before, in Chapter 36, "The Basics of Volatility Trading." Figure 36-3 showed the implied volatility of OEX options. Since that graph will be referred to several times in this chapter, it is reproduced here as Figure 41-2. These futures prices are points on that graph. For example, if all the futures were priced along the lower boundary in Figure 41-2, there would be an upward-sloping term structure. If they were priced along the upper boundary, there would be a downward-sloping term structure.

A positive-sloping term structure usually exists during bullish markets and/or if VIX is quite low-priced. A negative-sloping term structure usually exists during the throes of an ongoing bear market, especially if VIX is high-priced. For example, during the last few months of 2008 and off and on until March 2009, there was a severe *negative* slope to the term structure of the VIX futures. So a bullish stock market will cause the term structure to slope upward; the more bullish the market is, the steeper the term structure will slope upward. But when the market begins to decline, that upward slope will lessen. Furthermore, if the stock market *continues* to decline, the term structure will move from a

FIGURE 41-2.
Implied volatilities of OEX options over several years.



positive slope, to a flattened state, and eventually to an inverted (negative slope) if an ongoing bear market gets underway.

In these regards, the term structure can sometimes be a good indicator of whether the market is overbought or oversold, for if the term structure slopes "too steeply" in one direction or the other, odds are that it will flatten out somewhat, and the stock market will reverse direction—at least temporarily—in order for that to occur.

Novice traders often ask why these futures trade at such different prices than VIX, even the short-term ones. Besides the natural term structure of option pricing, as shown in Figure 41-2, there is another important factor—the way that VIX is computed as compared to what the VIX futures measure. Recall that, in the VIX calculation, one uses the two near-term strips of SPX options, whereas the futures only track the SPX options that expire 30 days hence.

As an example, examine what happened in August 2011, when VIX exploded to 48 as the stock market collapsed, but VIX futures didn't come close to that level. When VIX closed at 48 on August 8, 2011, the near-term (front-month) August VIX futures settled at 36.55—a huge discount of 11.45. The September futures (second month) discount was a rather stupendous 17.80 on that day, for the September VIX *futures* settled at 30.20.

When traders see prices like this, they might react with comments such as "Are these futures traders crazy? Why are they keeping the futures so far below VIX? Don't they know that stocks are collapsing?" The futures prices don't have anything much to do with traders' opinions. Rather, the reason this pricing occurs is that VIX and the futures do not have the same components. VIX and VIX futures prices are based on the implied volatilities of SPX options. On that date, VIX was a weighted calculation of the August and September SPX options. The VIX *futures* however, are based on just *one* strip of SPX options—those that expire 30 days after the VIX futures expiration. Hence, on that date of August 8, August VIX futures were based on the SPX September options. Similarly, September VIX futures were based on SPX October options.

Let's look at the details, to see why these large discounts occurred. Table 41-1 shows the implied volatilities of certain SPX options at the close of trading on August 8, 2011. VIX is effectively a weighted combination of the implied volatilities in the columns labeled "August" and "September."

August futures, however, are a combination of only the options in the column labeled "September." September futures are a combination of only the options in the column labeled "October." So it is quite easy to see why VIX is so much higher priced than the August futures, and why August futures are higher in price than September futures. It all has to do with the implied volatilities being paid for SPX options—and those are far more expensive in the "August" column.

Eventually such a discount will disappear—at expiration, certainly, if not sooner.

TABLE 41-1.
SPX Implied Vols 8/08/2011.

SPX: 1119.46, –79.92

Strike	August	September	October
1000	61.6%	43.4%	37.9%
1025	60.0	42.2	36.9
1050	57.8	40.9	35.7
1075	55.2	39.4	34.6
1100	52.0	37.8	33.2
1125	49.0	36.2	32.0
1150	45.7	34.5	30.7
1200	39.7	31.2	28.3
Futures	Xxx	**Aug futures: 36.55**	**Sept futures: 30.20**
VIX	**48.00**		xxx

It might be instructive to see how the term structure changed at a few extreme times in the past. When VIX futures first began trading, in 2004, VIX was quite low since a full-fledged bull market was in force. In fact, VIX stayed low until early 2007. But, on February 27, 2007, the Chinese raised margin rates, causing markets to fall all around the world. China's stock market fell by 8%, the Dow fell by 400 points, and SPX dropped 50 points—all in one day. This was quite a shock coming after such a long period of low volatility. The behavior of the futures was unusual. Table 41-2 shows the term structure before and after the market implosion that day.

TABLE 41-2.
VIX derivatives' behavior, February 2007.

	Feb. 15, 2007	Feb. 27, 2007	Pct change
VIX	10.22	18.31	+ 79%
March futures	11.55	14.80	+ 28%
April futures	12.60	14.50	+ 15%
May futures	13.40	14.40	+ 7%
June futures	13.80	14.40	+ 4%
July futures	14.15	14.55	+ 3%
August futures	14.55	15.10	+ 4%
Nov futures	15.10	15.15	+0.3%

There is quite a bit of telltale information in Table 41-2. First, notice how much VIX increased compared to the various futures contracts. Essentially, the term structure went from an upward-sloping one on February 15 to a somewhat downward-sloping one on February 27. And while none of the futures really kept pace with VIX, the near-term March contract was clearly better than any of the others. This is the first example of many that will show that when one wants to simulate VIX—either for speculation or for protection of a stock portfolio—he must stay in the near-term contract.

One reason that the futures didn't really increase all that much on February 27, 2007, was that they seemed to be implying that the market was overreacting, and the bull trend would resume—and it did recover very quickly thereafter. Thus, when all of the futures trade at a discount to VIX (as they were on February 27), then the market is oversold, and a buy signal for the market ensues when VIX drops back down. Alternatively stated, a spike peak in VIX—especially when all of the futures are trading at a discount to VIX—is a buy signal for the broad stock market.

The fact that the futures didn't keep pace with VIX was a cause for much consternation amongst the relatively few traders who were trading the product at that time. After all, some forward-thinking individuals, who were not completely wrapped up in the ongoing, low-volatility bull market as the calendar turned toward 2007, figured that volatility had to increase sometime in the next year. So they bought August or November VIX futures. Imagine their disappointment when the first VIX explosion took place in February 2007, and their futures barely rose at all. There were many erroneous explanations given by the media and misinformed analysts for what happened. Some were pure folly. Others were close, but not really on the mark, such as citing the fact that SPX options are European exercise.

The correct reason is that long-term August and November volatility did not really rise much on that February day. Only the implied volatility of SPX March and April options did to any real extent. As we saw from the typical term structure graph (Figure 41-2), near-term option implied volatility is far more explosive than is longer-term option implied volatility. In this case, March and April options were the most explosive, with the heavier weighting in March options pushing VIX sharply higher. April options, on which *March* VIX *futures* were based, rose in line with *that* month's volatility only. Later months didn't budge much at all. Thus, if one is going to try to simulate an explosive move in VIX, he can't be in a long-term VIX futures or options. Rather, he must stay short-term and keep rolling his position forward each month or two.

Sometimes the longer-term months will react more violently, especially if "smart money" perceives that there is longer-term risk to the market. It seems that in February 2007, the most perceptive traders didn't feel that there was anything more than a short-term risk to the market—that the Chinese rate increase was just a one-time event. And they were right, as the market quickly resumed its upward trend in March, 2007.