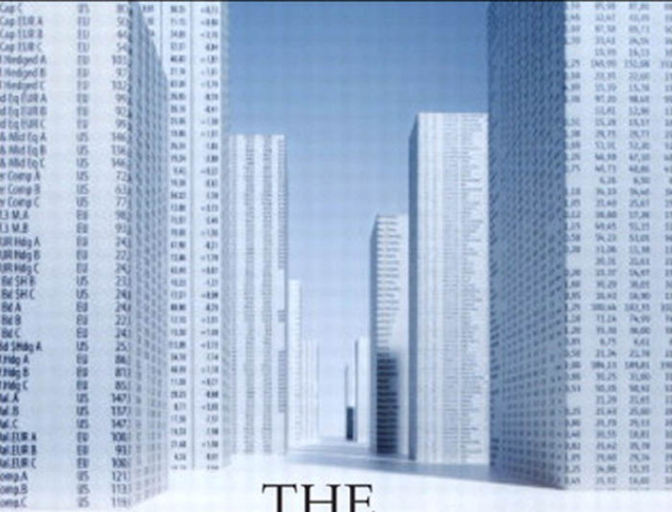

THE OPTION TRADER'S WORKBOOK

A Problem-Solving Approach

JEFF AUGEN

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Preface

There are two kinds of successful investors: those who admit to occasionally losing money and those who don't. Despite claims to the contrary, every investor loses money because risk always scales in proportion to reward. Long-term winners don't succeed by never losing; they succeed because their trades are well thought out and carefully structured. That said, very few investors recognize the impact of their own trading mistakes.

These mistakes can be subtle. The classic example goes something like this:

1. "I bought calls."
2. "The stock went up, but I still lost money!"

This frustrating scenario in which an investor correctly predicts a stock's direction but loses money is incredibly common in the option trading world. Leverage is almost always the culprit. More precisely, it is the misuse of leverage that stems from a fundamental misunderstanding of risk that so often turns investing into gambling with the simple click of a mouse. Option traders are famous for this mistake. They know, for example, that a sharp rise in the price of a stock can generate tremendous profit from nearly worthless far out-of-the-money calls. But lead is not so easily transmuted into gold. The problem is entangled with complex issues like collapsing volatility, accelerating time decay, and regression toward the mean. Institutional traders understand these issues and they rarely make these mistakes. Thousands of trades have taught them that not losing money is the very best way to generate a profit.

It's the thousands of trades, winners and losers both, that separate professionals from amateurs. Option trading is just like playing chess: It requires study and practice. The comparison is more valid than you might think. Both chess and option trading are governed by a complex set of rules. Risk analysis is at the center of both games; so is positional judgment and the ability to react quickly. Chess players learn to identify patterns; option traders, in their own way, must learn to do the same.

This book is constructed around these themes. It is designed to let investors explore a vast array of rules and trade structures by solving real-life problems. This approach differs markedly from the catalog of structured trades that seems to have become the contemporary standard for option trading books. Many fine texts have been written on the subject, but most build on this design with slightly different organization or a few novel trading ideas. Collectively they miss the point. Learning to trade options is an active process, best accomplished through doing rather than reading and memorizing. In this regard we have avoided the familiar but bewildering list that includes names like "reverse diagonal calendar spread," "condor," and "short strangle." In their place you will find more descriptive phrases like "sell the near-dated option and buy the far-dated option." But, more importantly, these descriptions appear in the context of trading situations in which the reader is asked to make a choice, predict an outcome, or design a correction. Moreover, the problems build on each other with each section progressing from basic to advanced.

Our goal was to challenge option traders at all levels. So take your time, work through the problems at a comfortable pace, and, most important of all, make your trading mistakes here instead of in your brokerage account.

1

Pricing Basics

The financial markets are a zero sum game where every dollar won by one investor is lost by another. Knowledge and trading tools are the differentiating factors that determine whether an investor lands on the winning or losing side. This book is designed to help investors expand their knowledge of pricing and trading dynamics. The problems are designed to be solved using basic principles and simple tools such as paper, pencil, and a calculator or spreadsheet program. Although you are strongly encouraged to become familiar with the use of an option pricing calculator, that skill will not be required to complete the problems in this book. However, it is always advantageous to explore different pricing scenarios with an option calculator and, in this context, you are encouraged to expand the problems and concepts that appear throughout the book.

That said, such calculators are the most basic and essential tool for an option trader. Their function is normally based on the Black-Scholes equations that describe the relationship between time remaining in an option contract, implied volatility, the distance between the strike and stock prices, and short-term risk-free interest rates. Suitable versions are included in virtually every online trading package offered by a broker in addition to dozens of examples that can be found on the web. For example, the Chicago Board Options Exchange (CBOE) has an excellent set of educational tools that includes a fully functional options calculator. Readers are encouraged to visit this and other option trading sites and become familiar with such tools. More sophisticated calculators are available in the form of position modeling tools sold by a number of software vendors.

Many traders would argue that they don't need to understand option pricing theory because the markets are efficient, and options, if they are relatively liquid, are always fairly priced. That view is flawed—there are many reasons to understand pricing. Suppose, for example, that you are faced with the choice of buying one of two identically priced call options that differ in strike price, volatility, and time remaining before expiration. A logical choice can only be made by a trader who understands the impact on price of each of these components. Structured positions composed of multiple options have more complex dynamics that bring pricing theory even more sharply into focus. Moreover, implied volatility, a principal component in the price of every option contract, varies considerably over time. It normally rises in anticipation of an earnings announcement or other planned event and falls when the market is stable. Successful option traders spend much of their time studying these changes and using them to make informed decisions. Generally speaking, they try to sell volatility that is overpriced and purchase options that are underpriced. Sophisticated institutional investors extend this approach by constructing refined models called "volatility surfaces" that map a variety of parameters to a three-dimensional structure that can be used to predict options implied volatility. Custom surfaces can be constructed for earnings season, rising and falling interest rate environments, bull or bear markets, strong or weak dollar environments, or any other set of conditions that affects volatility in a time or price-specific way. Regardless of the complexity of the approach, pricing theory is always the foundation.

Options are enormously popular derivatives, and many strategy-specific subscription services have sprung up on the web. This approach raises an important question: Is it better to choose a strategy and search for trade candidates, or to select stocks to trade and be flexible about the right strategy? Surprisingly, most option traders gain expertise trading a small number of position structures and search for candidates that fit. This search typically involves the use of charting software and a variety of tools for filtering stocks according to selectable criteria. Today's online brokers compete for active traders by continually upgrading the quality of their tools. Readers of this book are strongly encouraged to compare the offerings of different brokers to find those that best fit their needs. These tools combined with web-based services that provide historical stock and option prices can be used to construct a comprehensive trading and analysis platform.

Regardless of the approach—strategy or stock specific—pricing is the core issue. Buying or selling options without thoroughly understanding the subtle issues that impact their price throughout the expiration cycle is a mistake. We therefore begin with a chapter on pricing. Our approach is practical with a focus on trading. The concepts presented will form the basis for everything that is to follow, from basic put and call buying to complex multipart positions.

Unless otherwise stated, all examples for this chapter assume a risk-free interest rate of 3.5%.

1. A call option with a strike price of $100 trades for $3.00 with 14 days remaining before expiration. What must the stock price be at expiration for the option to still be worth at least $3.00?

   Answer: The stock price must be at or above $103 at expiration.

2. A put option with a strike price of $100 trades for $3.00 with 14 days remaining before expiration. What must the stock price be at expiration for the option to still be worth at least $3.00?

   Answer: The stock price must be at or below $97.

3. Suppose in each of the two examples described above, the stock was $15 out-of-the-money when the option traded for $3.00 with 14 days remaining. What can we conclude about the volatility of the underlying stock?

   Answer: The volatility must be very high for the option to be this expensive with only 14 days remaining before expiration and the stock 15% out-of-the-money. (Actual implied volatility is greater than 100% for each of these examples.)

4. A stock must continually move in the direction of the strike price to offset the effect of time decay. Assume the following:

Stock Price	**Call Price**	**Days Remaining**
$90	$2.22	100
$95	$2.22	50

   Can you determine the strike price without knowing the implied volatility or risk-free interest rate?

   Answer: $100. For the call price to remain constant, the stock must trace a nearly straight path from its initial price to a point equal to the strike price plus the initial value of the call (in this case, $100 + $2.22). If the stock price climbs above this line at any point in the expiration cycle, the call option will rise above its initial value. Conversely, if the stock fails to keep pace and falls below the line, the call price will fall below its initial value. Figure 1.1 plots the number of days remaining on the y-axis and the stock price on the x-axis for this scenario.

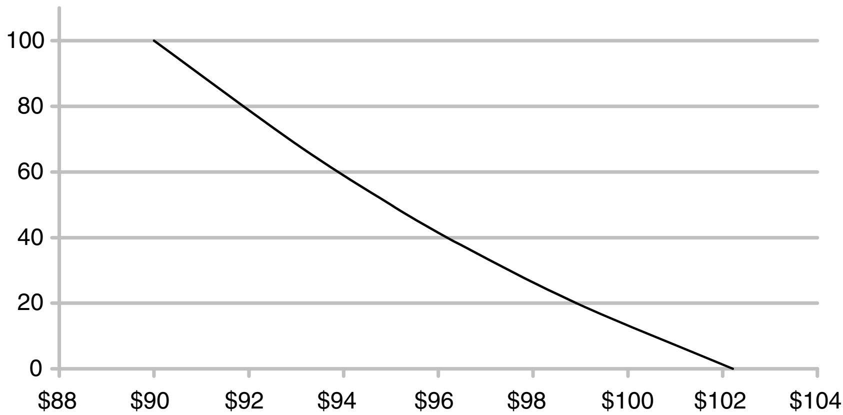

Figure 1.1 Stock prices required to offset time decay in question #4. (Days remaining on the y-axis.)

5. Implied volatility for the call option in question #4 was 28.5%. In general terms, what would be the effect of doubling or tripling the implied volatility?

   Answer: Increasing the volatility priced into the option contract would raise the value of the midpoint ($95 with 50 days remaining in problem #4), and endpoint ($102.22 at expiration in problem #4). The new initial option price would be much higher; the stock price would need to climb much faster; and the expiration price would need to be much further in-the-money for the option to maintain its value. For example, in an extreme case where 200% implied volatility is priced into the same option, the initial price with 100 days remaining would be $33.37. To sustain this option price with 50 days remaining, the stock would have to trade at $106.52. At expiration the stock would need to trade $33.37 in-the-money—that is, the stock would need to close the expiration cycle at a price of $133.37.

6. Risk-free interest for the scenario in question #4 was 3.5%. What would be the effect of significantly increasing the rate of risk-free interest priced into the option contracts?

Answer: Raising the value of risk-free interest also increases the option price. As a result, the initial value with 100 days remaining would be higher, the midpoint stock price that would have to be reached to maintain this price would be higher, and the stock would have to expire further into-the-money to maintain that price. However, the interest rate effect is much more subtle. If, for example, we used an extraordinary rate ten times larger than that of the original scenario—that is, 35%—then the table in question #4 would contain the values in the following table:

Stock Price	**Call Price**	**Days Remaining**
$90.00	$4.96	100
$97.03	$4.96	50

The midpoint with 50 days remaining has climbed to $97.03, and the stock would need to climb to $104.96 at expiration for the option to maintain its price. The subtle nature of the interest rate effect is apparent when one considers that this relatively small distortion required a hyperinflation value of 35%. However, the linear relationship between offsetting stock price and time decay is preserved despite the extreme nature of the example. As always, the stock price must follow a linear trajectory that ends at a point equal to the strike price plus the initial option value for the call option price to remain constant.

7. You might have noticed that the line displayed in the chart accompanying question #4 is not perfectly straight. Can you explain the subtle distortion?

   Answer: Time decay, also referred to as "theta," accelerates as expiration approaches. To maintain the option price, accelerating time decay must be offset by larger moves of the underlying stock. Some of the time decay acceleration is offset by increased sensitivity of the option price to underlying stock moves (delta rises as the stock approaches the strike price). However, the two forces do not exactly cancel. The difference gives rise to the subtle distortion and the line becomes a slight curve. Accelerating time decay similarly affects puts and calls. Figure 1.2 displays the same curve for a put option with a $90 strike price and the same implied volatility (28.5%). The constant price is $1.78. As before, the y-axis displays the number of days remaining and the x-axis the stock price.

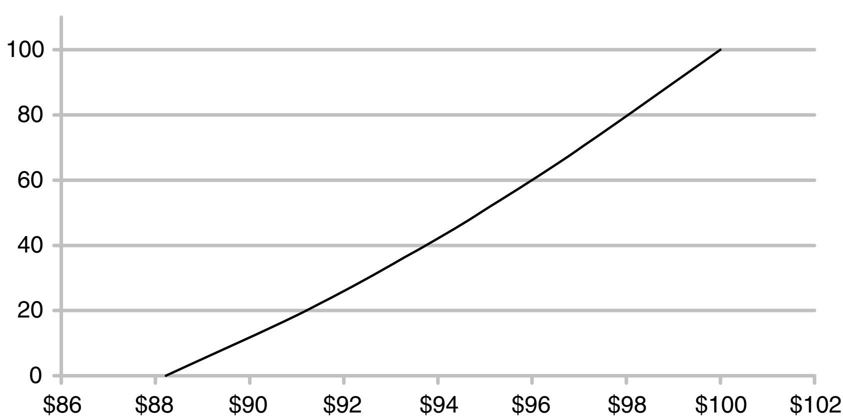

Figure 1.2 Stock prices required to offset time decay for a $90 put with 28.5% implied volatility. (Days remaining on the y-axis.)

8. For a stock trading at \$100, which option is more expensive—\$105 call or \$95 put? (Assume implied volatility, expiration date, and so on, are all equal.)

   Answer: \$105 call. Option pricing models assign more value to the call side. This asymmetry of price is related to the lognormal distribution that underlies all pricing calculations. In simple terms, if a \$100 stock loses 50% of its value twice, the stock will trade at \$25. However, if the same stock experiences two 50% increases, it will rise \$125 to \$225. This effect causes calls to be more expensive than corresponding puts at the same strike price. Thus, a sequence of price changes that generates a 75% loss can be reversed to yield a 125% gain. These results imply that calls should be priced higher than puts at the same strike price.

9. If XYZ is trading at \$102.50 and the \$100 strike price call is worth \$3.00, would it be better to exercise or sell the option?

   Answer: It rarely makes sense to exercise an option because all remaining time premium is lost. In this case we are told that the option is worth \$3.00 but only \$2.50 would be realized by calling the stock (we would buy the stock for \$100 and sell for \$102.50). This dynamic holds until the final minutes of trading when all premium disappears from the contracts. In practice, the final trade of an option contract usually lands in the hands of a broker who can exercise in-the-money contracts for very little cost.

10. Suppose you are short the calls mentioned in problem #9 (stock is \$2.50 in-the-money and calls are trading for \$3.00). How much money would be saved if the stock is called away from you?

    Answer: 50¢.

11. Assume that it is expiration day and you are short at-the-money calls on a \$100 stock—that is, the stock is trading right at the strike price. What are the risks associated with letting the option be exercised? If you already own the stock (covered calls), does it make sense to let it be called away?

    Answer: All remaining time premium will disappear during the final few hours of trading. If, for example, the option is worth 70¢ at the open and the stock remains at the strike price, the option price will decline to just a few cents by the close. However, the option price is very sensitive to changes that might occur in the underlying stock; this effect is enhanced as the day progresses and the option price approaches zero. Consider, for example, how the stock price will affect the option price near the close when the option might be worth as little as a few cents. Furthermore, the risk increases after the market closes if the stock trades in the after-hours session. The risk disappears for covered calls because the stock has already been purchased. Buying back inexpensive calls on the final day makes sense when it is undesirable to have the shares called away for other reasons such as tax consequences or an expectation that they might trade higher when the market reopens. With regard to trading costs, it is less expensive to allow the stock to be called away than to buy back short calls.

12. Delta represents the expected change in an option's price for a 1-point change in the underlying security. If a $3.00 call option has a delta of 0.35, what will the new option price be if the stock suddenly rises $1.00?

    Answer: $3.35.

13. Suppose in question #12 the stock climbed $2.00. Would the new option price be more or less than $3.70?

    Answer: The new price will be higher because the call delta increases continuously as the stock rises. When the stock has risen $1.00, the new delta will be higher. Gamma is used to describe the rate of change of delta.

14. Why is gamma always positive while delta is negative for puts and positive for calls?

    Answer: Gamma represents the predicted change in delta for a 1-point move in the underlying stock or index. When the stock price rises, put and call deltas must both increase. The put delta becomes less negative and the call delta becomes more positive. In both cases gamma adds to the value of the delta. The opposite is true when a stock falls: The put delta becomes more negative and the call delta becomes less positive.

15. How is gamma affected by time and distance to the strike price? When does gamma have the highest value?

Answer: Gamma is highest when the underlying security trades near the strike price. Deep in-the-money and out-of-the-money options have the lowest gamma. These differences become more extreme as expiration approaches—gamma for at-the-money options rises sharply, and out-of-the-money gamma falls to 0. This behavior makes intuitive sense because at-the-money option delta rises very quickly as the stock moves beyond the strike price when expiration is near. Suppose, for example, that expiration is just 1 day away and the stock trades at the strike price of a call option. If the stock price climbs several dollars, delta will jump from 0.5 to 1.0 and gamma will fall to nearly 0. Conversely, if many months remain before expiration and the stock price climbs several dollars, delta will increase a substantially smaller amount and gamma will remain very small. These effects are illustrated in the table that follows, which depicts delta and gamma for a call option with a strike price of $110 when the underlying stock rises from at-the-money to $10 in-the-money. (Implied volatility of 50% was used for these calculations.)

Stock Price	**Strike**	**Days Remaining**	**Delta**	**Gamma**
$110	$110	1	0.51	0.136
$120	$110	1	1.00	0.001
$110	$110	366	0.63	0.007
$120	$110	366	0.69	0.006

16. How is gamma affected by volatility?

   Answer: Gamma falls as volatility rises for at-the-money options. Conversely, out-of-the-money options sometimes experience rising gamma when volatility rises. Every stock and strike price combination has a gamma peak at a specific implied volatility.

17. How is delta affected by volatility? How does this behavior vary with time?

   Answer: Near-dated, out-of-the-money options have substantial delta only if the underlying security is very volatile. At-the-money option delta is virtually unaffected by volatility changes, and delta falls sharply as volatility rises for in-the-money options. These effects make sense when they are recast in the context of risk management. A low volatility stock trading far from the strike price has little chance of ending up in-the-money; it has a characteristically low delta. Conversely, a highly volatile stock has a much greater chance of moving into-the-money and its delta is higher in proportion to this risk. Deep in-the-money call options have a small chance of falling below the strike if the stock has low volatility. The delta on these options will be close to 1.0. If the same stock displayed very high volatility, the price would have a reasonable chance of falling below the strike and the calls would display a significantly lower delta.

   These effects can be extended to explain the delta for options that have many months left before expiration. Out-of-the-money options have higher deltas than their near-expiration counterparts because they have much more time left to cross the strike price. Deep in-the-money long-dated call options have a lower delta than their near-expiration counterparts because they have much more time to fall below the strike price.

The following table summarizes this behavior. The left side displays delta values for call options on two different stocks with 18 days remaining before expiration, one with high volatility and one with low volatility. The right side repeats these parameters for calls that have one year left before expiration.

18 Days Remaining/$110 Strike			365 Days Remaining/$110 Strike		
Stock Price	**Volatility**	**Delta**	**Stock Price**	**Volatility**	**Delta**
$100	0.20	0.02	$100	0.20	0.42
$100	0.50	0.22	$100	0.50	0.55
$110	0.20	0.52	$110	0.20	0.61
$110	0.50	0.53	$110	0.50	0.63
$120	0.20	0.98	$120	0.20	0.76
$120	0.50	0.80	$120	0.50	0.69

18. Question #17 related delta to risk. How can the value of an option delta be used as a guide for structuring a hedge?

Answer: The delta value is approximately equal to the chance that an option will end up in-the-money. A call option with a delta of 0.35 should be expected to have a 35% chance of expiring in-the-money. At expiration, deep in-the-money calls have a delta of 1.0 and deep in-the-money puts have a delta of –1.0 because each is almost guaranteed to expire in-the-money. These options behave like long and short stock respectively—that is, their prices change dollar-for-dollar with the stock price.

Stock hedges can be constructed to protect short positions using these parameters. To fully hedge 10 naked calls having a delta of 0.35, a short seller would need to purchase 350 shares of the underlying security. The number of shares would need to vary as the stock rose and fell because the option delta would constantly change. It would also need to change to accommodate time decay and volatility swings in the underlying security.

19. What would you expect the call option delta to be for a stock that trades exactly at the strike price in the final few hours before expiration?

Answer: 0.50 because there is approximately a 50% chance that the stock will close in-the-money.

20. For every straddle there is an underlying price point where the call and put deltas are each exactly equal to 0.5. This parameter, known as the "delta neutral point," depends on several factors, including implied volatility, time remaining before expiration, and price of the underlying stock or index. When is the delta neutral point exactly equal to the strike price? Why is it not always equal to the strike price?

Answer: The delta neutral point of a straddle begins below the strike price and rises at a constant rate until it equals the strike price at expiration. The same distortion that causes calls to be more expensive than puts sets the delta neutral point below the strike price (see question #8). Consequently, if a stock trades at the strike price of a straddle prior to expiration, the price and delta of the put will both be higher than those of the corresponding call.

21. Suppose with 300 days remaining before expiration, a put-call option pair with a strike price of $100 is exactly delta neutral with the stock trading at $87.66. When the new delta neutral point is $93.83, how many days will be left before expiration? At $96.92 how many days will be left?

Answer: 150 days at $93.83 and 75 days at $96.92. The steady movement of the delta neutral point is displayed in Figure 1.3. Days remaining before expiration are displayed on the y-axis, and the delta neutral stock price is displayed on the x-axis.

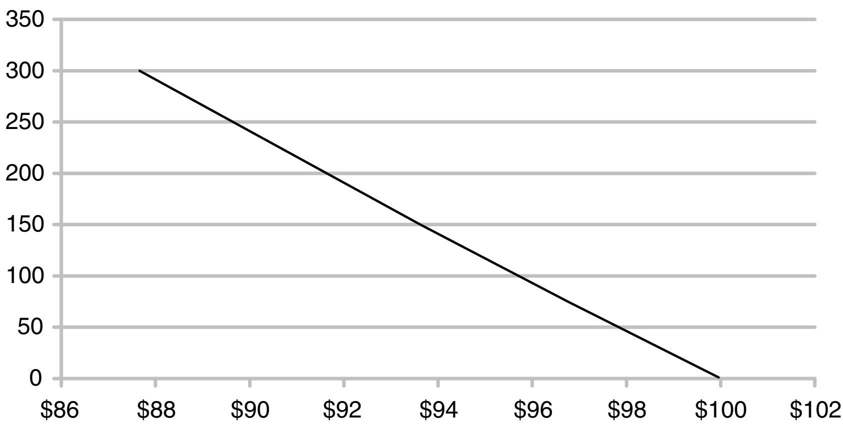

Figure 1.3 Migration of the delta neutral point for $100 strike price straddle beginning 300 days before expiration. Options for this example were priced with 50% implied volatility.

22. How would the slope of the line displayed in the answer to question #21 be affected if the implied volatility for both the put and the call were reduced by half?

Answer: The slope of the line becomes steeper because the starting price is closer to the strike. As volatility approaches zero, the slope of the line becomes vertical. If volatility vanished entirely, the line would be vertical and the delta neutral point would always be the strike price. The difference between 50% volatility and 25% volatility is displayed in Figure 1.4. As before, the number of days remaining is measured on the y-axis and the delta neutral stock price appears on the x-axis.

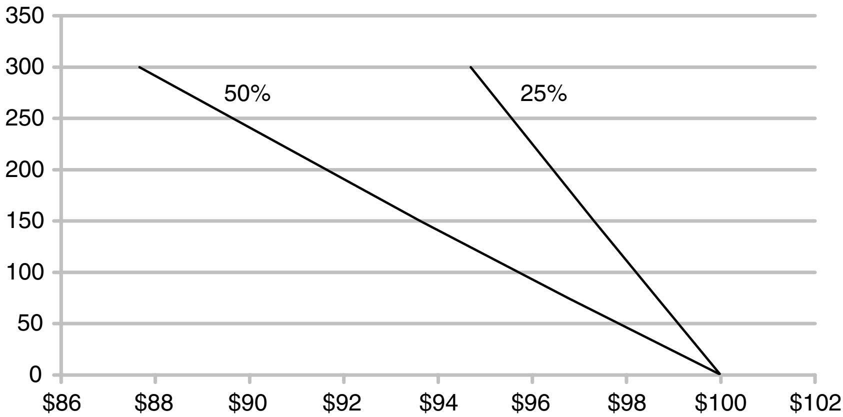

Figure 1.4 Delta neutral point migration measured using 50% and 25% volatility for a $100 strike price option beginning 300 days before expiration.

23. Consider a position composed of long deep in-the-money calls and short deep in-the-money puts for a stock trading at $100, as shown in the following table:

Stock Price	$100
$90 call (long)	delta = 0.79
$110 put (short)	delta = –0.70

What will the delta of each side be if the stock remains at $100 until expiration?

Answer: $90 call delta = 1.0 and $110 put delta = –1.0 at expiration with the underlying stock trading at $100.

24. Suppose that in question #23 the $90 call originally cost $12.30 and the $110 put sold for $12.05—that is, the total position had a net cost of only 25¢. What was the final gain or loss?

Answer: At expiration the call and put were each worth $10.00, so the final position was long $10.00 (call) and short $10.00 (put) with a net value of $0.00. Therefore, the trade lost $0.25.

25. Assume that the trade in questions #23 and #24 was long 10 calls and short 10 puts. Can you calculate the collateral requirement for the trade? What was the total cost of owning the position?[1]

Answer: It is necessary to set aside 20% of the value of the underlying stock for the short side of the trade. Since we sold 10 put contracts for a $100 stock, the cost would be 0.20 × $100 per share × 10 contracts × 100 shares per contract = $20,000. We must add the value realized from the sale of the put ($12,050 + $20,000 = $32,050).

On the long side we would need to have enough cash on hand to purchase the calls = $12.30 × 10 contracts × 100 shares per contract = $12,300. Therefore, the account must have $44,350 to execute the initial trade. At expiration $0.25 was lost = $0.25 × 10 contracts × 100 shares per contract = $250. The total cost of holding the trade was $250 plus opportunity cost on $44,350 during the lifetime of the trade.

[1] Collateral and margin requirements for option traders can vary by broker. Furthermore, recent changes allow customers whose accounts exceed certain minimum thresholds to take advantage of portfolio margining rules which more precisely align collateral requirements with overall portfolio risk. Readers wishing to further explore margin and collateral requirements are encouraged to visit the Chicago Board Options Exchange website and to contact their broker.

26. Consider a position composed of long out-of-the-money calls and long out-of-the-money puts for a stock trading at $100, as shown in the following table:

Stock Price	$100
$110 call (long)	delta = 0.30
$90 put (long)	delta = –0.21

What will the delta of each side be if the stock remains at $100 until expiration? What will the options be worth?

Answer: $110 call delta = 0 and $90 put delta = 0 at expiration with the underlying stock trading at $100. Both options lose all their value.

27. Over what range of stock prices will the loss at expiration be 100%?

Answer: Both options will expire worthless with the stock between $90 and $110. The total range for a return of $0.00 is $20.00. Outside this range, one of the options will have some value.

28. Assume that the calls in question #26 cost $2.56 and the puts cost $1.86. At expiration, what underlying stock prices are break-even points for the trade? Is any collateral required for this position?

Answer: The total cost was $4.42. Break-even points are $114.42 on the upside and $85.58 on the downside. These values are determined by adding $4.42 to the $110 call strike and subtracting $4.42 from the $90 put strike. No collateral was required because both sides were long. The trade would have originally cost $442 for each pair of contracts.

29. Assume that the trade originally described in question #26 decays to $0.00 with the stock at $100 and 1 day left before expiration. An unsubstantiated rumor surfaces that the stock in question might be acquired, and implied volatility soars to very high levels. Is there a level of implied volatility that could restore the price of each option to its original value despite being $10 out-of-the-money with only 1 day left? Would put and call deltas also be restored?

Answer: Yes, as long as there is time left in the contracts, it is possible for volatility to rise high enough to restore the original prices and deltas. If, for example, the original implied volatility was 40% and 50 days remained before expiration, a new implied volatility around 280% would restore the original values. Option prices on both sides of the trade would regain their original sensitivity to underlying price changes. However, because the delta-neutral point of the position would have shifted slightly over the 50 days that the trade was open, the new call price would be a few cents lower and the put price a few cents higher to achieve the same overall position value. These distortions are very slight for options that are 10% out-of-the-money. Actual values are listed in the following table.

Days Remaining	Put ($)	Call ($)	Volatility	Delta
50	1.86		0.40	–0.21
50		2.56	0.40	0.30
1	1.98		2.78	–0.22
1		2.45	2.78	0.29

30. Which of the following call options suffers the greatest time decay (highest theta)?

Stock Price ($)	Strike	Days Remaining	Call ($)	Volatility
95	100	70	4.84	0.4
100	100	5	1.90	0.4

Answer: The second entry in the table suffers from much greater time decay. In broad terms, if the underlying stock remains at $100, this option will lose $1.90 of value over 5 days (an average of 38¢ per day). Conversely, the first entry in the table will lose $4.84 of value over 70 days (an average of only 7¢ per day). These numbers, although useful for quick comparisons, are average values across the entire timeframe. In the first entry with 70 days remaining, actual theta is equal to 5¢ per day; in the second entry with only 5 days left, theta is equal to 19¢. Figure 1.5 displays theta values for a $100 strike price call with the stock price at $95 and implied volatility of 40% (first row of the table). Theta is measured on the y-axis and the number of days remaining before expiration on the x-axis. Note that theta increases on a steeply accelerating curve as expiration approaches. The shape of this curve can be described using a third-degree polynomial.

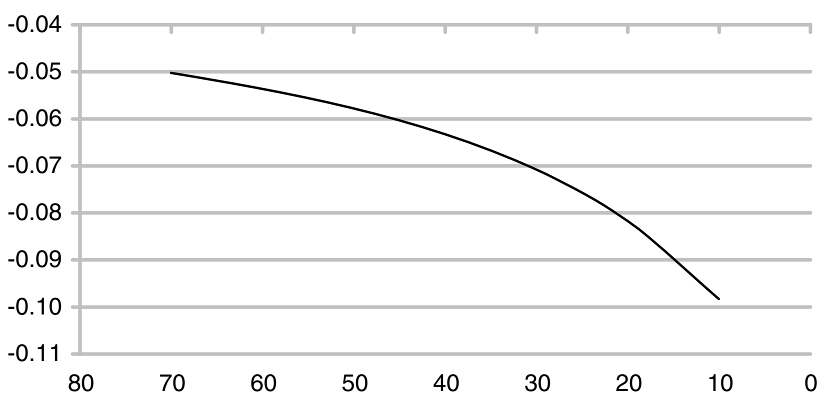

Figure 1.5 Time decay profile for a $100 strike price call with 40% implied volatility and the underlying stock trading continuously at $95.

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