SALOMON SMITH BARNEY

GLOBAL EQUITY RESEARCH: Equity Options **April 1998**

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The Salomon Smith Barney Introductory Guide to Equity Options

This report may be distributed only to persons who have received a copy of the booklet "Characteristics and Risks of Standardized Options," published by the Options Clearing Corporation.

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Preface

Preface

This guide introduces the reader to equity options, outlines the structure and mechanics of the markets, and describes and explains the many equity investment strategies that can be implemented with options. We keep the discussion at an introductory level and emphasize practical applications rather than formal finance and economics theory. The text is intended for professional equity investors and any market participants who desire an overview or short review of the equity options market and the many applications of options in the equity investment process.

The guide is organized into six chapters:

1. Introduction to Option Fundamentals

2. Option Contracts and the Equity Options Market

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5. Options Strategies

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The first chapter introduces the reader to some basic definitions and terminology and outlines the history and growth of the market. Chapter Two describes the structure and mechanics of the equity options market and some aspects of trading the contracts.

Chapter Three discusses the variables that determine the value or price of an equity option. The goal of this section is to provide some basic insight into the determinants of option value without undue mathematical rigor. Chapter Four describes what happens to an option's price as these variables change.

Chapter Five is the heart of the document and provides a practical guide for using equity options in a broad range of strategies and situations that are important to institutional and retail equity investors. In the final chapter, we present a brief overview of exotic options as well as an intuitive way of classifying them. Finally, we provide an options bibliography for interested readers.

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Chapter One

Introduction to Option Fundamentals

This chapter explains the basic concepts of equity options. In the first section, we briefly review the history of the equity options markets and document their dramatic growth. The second section introduces some of the basic definitions and terminology of options. Finally, we discuss the users of equity options and review some of their reasons for transacting in these instruments.

A. Brief History of Options

While many investors may believe that options are a product of recent financial innovation, options were, in fact, conceived thousands of years ago. Some market historians trace the origins of options as far back as ancient Greece and the philosopher Thales. In a fashion similar to some of today's stock market pundits, Thales used astrology one year to predict an abundant olive harvest for the following spring. Being a man of conviction, Thales negotiated a price that winter for the *option* to rent the local olive presses at the beginning of the forthcoming season. It so happened that his forecast was correct and a record crop was harvested. As a result, Thales exercised his option, took possession of the olive presses, and then leased them back to the farmers at a highly profitable rate.

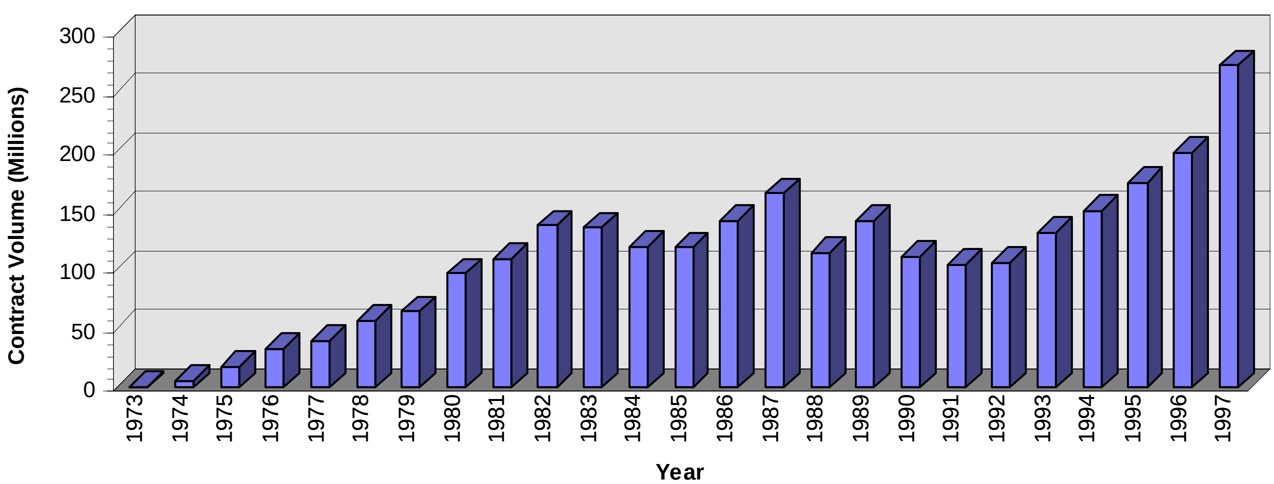
There are numerous other examples to cite in the long and colorful history of options. For example, the ancient Phoenicians and Romans traded contracts on the goods transported by their merchant vessels with terms resembling those of options. During the infamous tulip bulb craze in seventeenth century Holland, tulip farmers and dealers traded contracts that gave the owner the right to buy or sell specific types of bulbs for a specified price in the future. Similarly, after the British government granted the South Sea Company a trading monopoly in the lucrative South Pacific in the eighteenth century, speculators frenetically bought that company's stock. This eventually led to the creation of contracts that entitled investors to buy or sell the stock for a specified price at a later date.

In the United States, stock options began trading in the late eighteenth century and grew into a large over-the-counter business by the middle of the twentieth century. During this period, options were customized contracts whose specific terms were privately negotiated and agreed upon by the buyer and seller. The standardized equity options that dominate today's market began trading on the Chicago Board Options Exchange (CBOE) on April 26, 1973. Today, thousands of standardized options contracts on individual stocks, stock indexes, government bonds, currencies, precious metals, and futures contracts trade at some 57 exchanges in 27 countries throughout the world.

B. The Growth and Development of Equity Options

The U.S. and global equity options markets have grown significantly over the past three decades. In Figure 1 we show the annual volume of equity options contracts traded on all U.S. exchanges since inception. After the CBOE introduced exchange traded contracts on individual stocks in 1973, equity option trading grew as other exchanges, such as the American Stock Exchange (AMEX), the Philadelphia Stock Exchange (PHLX), the Pacific Stock Exchange (PCX), and the New York Stock Exchange (NYSE) began listing options. Following the lead of the U.S. exchanges, foreign exchanges also began to list contracts. Currently, individual stock options trade at 29 exchanges in 21 countries throughout the world. In the United States the universe of stocks that underlie options has grown from 16 in 1973 to over 2,600 in 1997. This dramatic market growth is a testament to the economic importance that investors place upon these financial instruments.

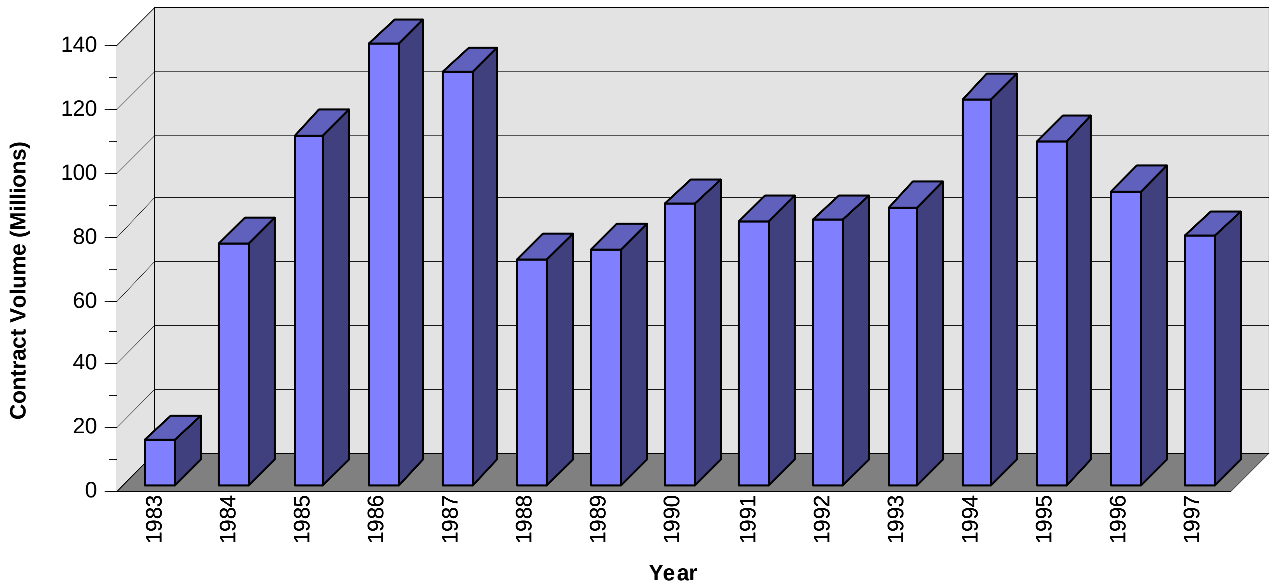
Figure 1. Annual Trading Volume of U.S. Listed Stock Options



Source: Chicago Board Options Exchange.

The development of the equity options market reached another important milestone in 1983 when stock index options were introduced. During March of that year, the CBOE began trading cash settled options on the Standard and Poor's 100 Index (OEX). Investors readily embraced this product, and options on the S&P 500 at the CBOE and the Major Market Index (MMI) at the AMEX followed later that year. In October of 1997 the CBOE introduced options on the well known and often quoted Dow Jones Industrial Average (DJIA). The growth in the volume of stock index options contracts traded on U.S. exchanges is shown in Figure 2.

Figure 2. Annual Trading Volume of U.S. Listed Stock Index Options



Source: Chicago Board Options Exchange.

Currently, over 100 stock index options contracts trade at 28 exchanges in 20 countries. In many instances, the notional value of the volume of an equity index option actually exceeds the value of the volume of the underlying stocks in the index. For example, in 1997, the average daily notional value of trading in S&P 100 options was $11.0 billion while the average daily value of the trading volume of the stocks comprising the OEX was $9.3 billion.

In addition to options on broad market based equity indexes, exchanges have also been listing options on indexes that measure the performance of smaller market segments such as economic sectors and industry groups. In the United States alone there are currently over 60 industry or sector index options traded on four different exchanges.

C. Basic Definitions

Options belong to the broad category of securities known as **derivatives** or **contingent claims**. A derivative is a contract or agreement whose value is *derived from* or *contingent upon* the value of a related asset that is referred to as the *underlying* asset. In exchange for a payment called the option premium, which is the price of the option in the marketplace, an option contract gives the option owner or holder the right, but not the obligation, to buy or sell the underlying asset (or to settle the value for cash) at a specified price any time during a designated period or on a specified date.

It is important to note that the owner of an option can also choose to not exercise the option and to let it expire worthless. So by exercising, the owner benefits from a favorable move in the price of the underlying, and by not exercising, the owner does not suffer the loss that results from an unfavorable move. In contrast, the seller or writer of an option is always obligated to fulfill the terms of the contract if it is exercised by the owner.

There are six specifications or terms that uniquely and completely define an option contract: option type, underlying asset, strike price, expiration date, exercise style and contract unit. We briefly define these terms in the following and discuss them in more detail in Chapter Two.

Option Type

There are two types of simple options, calls and puts. A **call option** gives the holder the right, but not the obligation, to buy the underlying asset at a predetermined price on or by a certain date. A **put option** gives the holder the right, but not the obligation, to sell the underlying asset at a predetermined price on or by a certain date.

Underlying Asset

Options are available on a large and diverse group of underlying assets including individual stocks, stock indexes, government bonds, currencies, precious metals, and futures contracts. In this report we will discuss only those options whose underlying asset is an individual stock, a stock index, or a stock index future. The underlying asset of an individual stock option is a given number of the actual shares of the underlying stock. The underlying asset of a stock index option is an amount of money in a designated currency equal to some multiple of the index value. Finally, the underlying asset of a stock index futures option is a futures contract and is therefore a derivative on another derivative.

Strike Price

The strike price, also called the **exercise price** is the price at which the option owner can buy or sell the underlying asset.

Expiration Date

The expiration date is the date on which the option and the right to exercise it cease to exist.

Exercise Style

There are two primary exercise styles, American and European. **American options** can be exercised at any time before the expiration date, while **European options** can be exercised only on the expiration date.

Contract Unit

The contract unit is the *amount* of the underlying asset that the option owner can buy or sell for the strike price upon exercise. In the United States, the contract unit for individual stock options is 100 shares of stock, for stock index options it is an amount of money equal to $100 times the index value,

and for stock index futures options it is one futures contract. Therefore, a call option quoted at a price of $5 and struck at $50 entitles the owner to buy 100 shares of the underlying stock for $5,000 at a later date. The price that the owner pays for this right is $500.

Other useful definitions include the following:

Opening and Closing Transactions

An **opening transaction** is one that increases the number of long or short contracts in an account. A **closing transaction** offsets prior trades and involves buying options to reduce the number of contracts in an existing short position or selling options to reduce the number of contracts in an existing long position.

Option Holder and Writer

The party who buys an option in an opening transaction is referred to as the **option holder.** Conversely, the party who sells an option in an opening transaction is known as the **option writer**. The holder is said to have a long position, and the writer is said to have a short position.

Exercise

An option holder who decides to buy or sell the underlying stock in exchange for the strike price is said to exercise the option. Call option holders buy the underlying stock from the option writer and put option holders sell the underlying stock to the option writer.

Assignment

When an option holder exercises an option, an option writer is assigned the obligation to fulfill the terms of the option contract. Specifically, this requires the call option writer to deliver stock and the put option writer to take delivery of stock.

Classes and Series

An **option class** is defined as all options of the same type on the same underlying asset. For example, all IBM call options comprise a separate class as do all GM puts. A **series** consists of all members of the same class that have the same strike price and expiration date. For example, all IBM July 100 puts comprise a separate series as do all GM June 60 calls.

D. Users of Equity Options

Investors use equity options for two basic reasons:

- To modify the risk and return characteristics of an equity portfolio, and
- To substitute for the underlying stock.

1. Modifying Risk and Return

Derivatives in general and options in particular enable investors to create risk and return profiles that are either unobtainable with the underlying stocks or too expensive to duplicate with the underlying stocks. Three common strategies that are implemented to restructure the investment payoff are hedging, enhancing returns, and isolating sources of return.

a. Hedging

Hedging essentially involves reducing or removing the risk from an investment. Hedging is implemented by establishing a second position whose price moves opposite to that of the initial position. As the value of the original position increases or decreases, the value of the second position decreases or increases by the same amount. The value of the overall hedged position thus remains constant. Investors use options and other derivatives for hedging because these instruments can be combined to create positions whose prices move opposite to those of existing equity portfolios. For example, an equity investor who fears that the price of a stock that he or she owns is about to decrease can hedge the stock by buying a put option. As we will see, if the stock price does decrease, the price of the put will increase by a similar amount.

b. Enhancing Returns

Obtaining higher yields or enhanced returns is another major application of options. Arbitrage strategies enhance returns by capturing the difference between the theoretical value of an option and its actual market value. Other popular option-based return enhancement strategies convert future price returns into current income.

c. Isolating Sources of Returns

Options enable investors to isolate sources of return that are typically bound together in the underlying cash market instruments. For example, an investor who purchases foreign equity is exposed to three sources of return: (1) currency return, (2) foreign market return, as captured by the stock's beta, and (3) stock specific return, as captured by the stock's alpha. If the investor has a view on which sources of return are attractive and which are unattractive, then he or she can use options to neutralize the unattractive sources (for example, the market source), while maintaining exposure to the attractive sources (for example, the currency and stock specific sources.)

2. Substituting for Stock Transactions

By using options, an investor can obtain efficient exposure to stocks or stock markets without transacting in the actual cash security because options are an effective substitute for the underlying asset. Speculators, long term investors, and asset allocators can use options to quickly and efficiently enter and exit their desired equity, fixed income, or cash markets. Options are often cheaper to buy and sell than the underlying asset, and options are often better vehicles for establishing short positions than the underlying asset. Options provide much more leverage than stocks, and taxable investors may find it more beneficial to transact in the options market instead of the cash market.

We will return to the subject of how investors use options to meet their investment objectives in Chapter Five where we discuss in detail the many investment and trading strategies that can be implemented with options. In the meantime, we now proceed to Chapter Two to examine in more detail the properties of equity options and their markets.

Chapter Two

Option Contracts And The Equity Options Market

In this chapter we discuss the structure and mechanics of the equity options market and some aspects of trading equity options. The first section describes the standardized terms that characterize listed contracts as well as some of the structural aspects of the listed market such as floor trading, clearing, settlement, transaction costs, and margin. In the second section we briefly mention some of the more important aspects of over-the-counter (OTC) equity options.

A. Exchange-Traded Equity Options

Prior to April 1973, individual stock options were traded only in the over-the-counter market. Investors who desired to buy or sell options contacted their brokerage firms who in turn bought or sold from a small group of independent option brokers. An independent broker either found another customer to take the opposite side of a trade or acted as a dealer and bought or sold the options for the firm's own account. The terms of the options were privately negotiated and tailored to meet the specific needs of the individual clients, so no two contracts were exactly alike. Consequently, it was difficult to trade a contract to a third party. The pre-1973 equity options market was therefore nonstandardized, illiquid, and very expensive because of the high bid/ask spreads and the numerous fees and commissions that had to be paid to the investor's regular broker and to the options dealer.

By the late 1960's, the demand for equity options was increasing and innovative solutions to the problems that plagued the existing OTC market were being developed. In 1969, the Chicago Board of Trade embarked upon a program to create a new exchange for the trading of stock options. On April 26, 1973, the new exchange opened as the Chicago Board Options Exchange (CBOE) and began trading call options on 16 individual stocks. These new options that traded at the CBOE differed from their over-the-counter predecessors in several significant ways. First, the terms of the contracts were standardized. Every contract on a given stock specified the exact same underlying unit, and only a limited number of strike prices and expiration dates were made available. Standardization facilitated trading and helped to create a liquid secondary market by reducing the number of available contracts, by making the contracts interchangeable or fungible, and by requiring buyers and sellers to negotiate only the option price.

Second, the exchange centralized the trading of options which increased liquidity and reduced transaction costs. Buyers and sellers could now easily find each other on the exchange floor and trade at prices that were determined fairly in an open auction atmosphere. Centralization also established a needed regulatory environment because the exchange created rules regarding contract limits, margin requirements, and trading halts during periods of market turbulence.

Last, the creation of the Options Clearing Corporation (OCC) completed the establishment of an active secondary market. The OCC acted as an intermediate organization that took the opposite side of every trade and guaranteed the new contracts. Previous OTC options could not easily be sold to a third party because their terms were customized in private negotiations between the buyer and seller. However, the new listed contracts did not connect the original buyers and sellers in any way because the OCC automatically took the opposite side of every trade. Consequently, traders could now easily liquidate their positions with offsetting transactions because they did not have to locate and trade with the original counterparties. Creation of the OCC also removed the credit risk from the buyer and seller and transferred it to the brokerage firms who were members of the clearing house.

The structure of the equity options market that emerged in 1973 as a result of the creation of the CBOE remains much the same today at the four U.S. equity options exchanges and at many of the 25 non-U.S. exchanges that list individual stock options. This market will be described in more detail in the remainder of this chapter.

1. Contract Standardization

As mentioned in Chapter One, an option contract is completely defined by six terms or specifications: the option type, the underlying stock or asset, the contract unit, the exercise style, the strike price, and the expiration date. These terms are standardized as follows:

a. Option Type

Options are listed as either calls or puts with each type being equally available. Contracts are created upon demand, and there is no limit on the total number of calls or puts that can exist at any given time. Physical certificates do not exist, and the only proof of ownership is the electronic entry on the books of the clearing house and the trade confirmation that is sent to the buyer and seller.

b. Underlying Stock

Stocks selected by an exchange to underlie options must meet certain criteria. For example, in addition to a reasonable level of investor interest, the general requirements of the CBOE are the following:

1) The price of the underlying stock must be at least $7.50 during the three months prior to listing.

2) The underlying stock must have at least 2,000 shareholders.

3) The trading volume of the underlying stock must be at least 2.4 million shares during the 12 months prior to listing.

4) The underlying stock must have least 7 million shares outstanding that are owned by investors who are not insiders or affiliates.

c. Contract Unit

The contract unit is the number of shares of the underlying stock that the option owner is entitled to buy or sell for the strike price at expiration. In the U.S. options market, the standard contract unit is one round lot of the underlying stock which is usually 100 shares. However, the contract unit can increase if the underlying stock undergoes a non-integer split during the lifetime of the option. For example, if the stock underlying an option splits 3 for 2, the split ratio is the fraction 3/2. In this case the contract unit increases to (3/2)(100) = 150 shares, the number of open contracts remains the same, and the stock price and strike price decrease by 2/3. However, if the stock splits 3 for 1 so that the split ratio is the integer 3, then the size of the contract unit does not change, but the number of open contracts increases by the split factor, and the stock price and strike price again decrease, this time by 1/3. In either case the product of the contract unit, number of open contracts, and the strike price stays the same. Other corporate actions such as stock dividends, recapitalizations, rights offerings, etc. are treated similarly. However, listed equity options are not payout protected, that is, no adjustments are made to the option price for cash dividends.

d. Exercise Style

There are only two possible exercise styles, American and European. American style options can be exercised on any business day during the life of the option, while European style options can be exercised only on the day of expiration. All individual stock options and options on stock index futures that are traded on U.S. exchanges are American style. However, the vast majority of U.S. listed stock index options are European style. The notable exception is the option on the S&P 100 index which is American style.

e. Strike Price

Strike prices are fixed 2 1/2 points apart if the underlying stock price is less than \$25, 5 points apart if the stock price is between \$25 and \$200, and 10 points apart if the stock price is \$200 or greater. New options are created with strike prices at or near the current stock price and at one interval above and below this strike. For example, if a stock currently trades at 51 3/4, then options with strikes of 45, 50, and 55 are initially listed. New series are added as the stock trades through the highest or lowest available strike prices.

f. Expiration Month

Stocks that underlie options are first assigned to either the January, February, or March quarterly expiration cycle. Then option contracts with four different expiration months are listed at any given time. These expiration months are the two nearest consecutive months and the two next nearest months in the assigned quarterly cycle. For example, if the January contract has just expired, then for the quarterly cycle shown on the left, the open contract months are shown on the right of the table below.

Quarterly Cycle	Open Contracts
Jan, Apr, Jul, Oct	Feb, Mar, Apr, Jul
Feb, May, Aug, Nov	Feb, Mar, May, Aug
Mar, Jun, Sep, Dec	Feb, Mar, Jun, Sep

Similarly, if the February contract has just expired, then for the same quarterly cycles shown on the left of the table below the open contract months are again shown on the right.

Quarterly Cycle	Open Contracts
Jan, Apr, Jul, Oct	Mar, Apr, Jul, Oct
Feb, May, Aug, Nov	Mar, Apr, May, Aug
Mar, Jun, Sep, Dec	Mar, Apr, Jun, Sep

So at any given time, four contracts are open: two that expire in the near term—one and two months; and two that expire in the far term—three and six months, four and seven months, or five and eight months.

The expiration day is also specified and is the Saturday after the third Friday of the expiration month for stock and stock index options listed in the United States. The last day on which contracts can be traded is the last business day preceding the expiration day which is usually the third Friday of the expiration month.

It should be noted that all four U.S. options exchanges also list special options that provide longer maturities. These contracts are known as LEAPS™ (Long-term Equity AnticiPation Securities) and are almost identical to conventional stock options except that their expiration dates are set as far as 39 months into the future. LEAPS were first introduced in 1990 by the CBOE and are also available on certain stock indexes. Besides having longer maturities, index LEAPS differ from conventional shorter-term index options in that the contract unit is an amount of cash equal to the index value times 10 instead of 100. (Note: The multiplier is 5 for the OEX LEAP.)

2. Market Structure

The structural and institutional details of the U.S. equity options market are outlined in the sections that follow.

a. Placing an Order

Options contracts are bought and sold through brokers who must be properly licensed by the appropriate regulatory agencies. A prospective investor who meets the necessary financial requirements opens a trading account with an options broker by signing appropriate documents including a securities account agreement, an options account agreement, and the OCC risk disclosure statement entitled "Characteristics and Risks of Standardized Options." When all of the paperwork is in order, the investor is then permitted to trade.

When placing an order, the customer must specify the following items:

- the type of order, i.e., a buy, sell, or spread order and whether the order is an opening or a closing transaction
- the type of option, i.e., a call or a put
- the number of contracts
- the underlying stock
- the strike price
- the expiration month
- the account number and the account type, e.g. margin or cash

With respect to the first item, the two most common types of regular buy and sell orders are a **market order** and a **limit order**. A market order is an instruction to buy or sell at the best possible price as soon as the order reaches the exchange floor. A limit order is an instruction to buy or sell only at a specified price or better. Limit orders are also designated as either **day orders** or **good-'til-canceled** (GTC). A day order automatically expires at the end of the trading day if it has not been filled. A GTC order remains in effect until it is filled, canceled by the customer, or the option expires.

A **spread order** is an order to buy and/or sell two options simultaneously as a package.

An **opening transaction** is one which increases the number of purchased or written options in an account. A **closing transaction** offsets prior trades and involves buying options to reduce the number of contracts in an existing short position or writing options to reduce the number of contracts in an existing long position.

b. Position Limits

The exchanges impose limits on the maximum number of options on the same underlying stock that an individual can buy or sell. The limits are proportional to the shares outstanding and the previous six-month trading volume of the underlying stock and are currently 25,000; 20,000; 10,500; 7,500; and 4,500 contracts. The limits apply to any combination of contracts that creates a position on the same side of the market. For example, a long call together with a written (short) put on the same stock counts as two contracts against the limit as does a long put together with a written call. The position limits are also the maximum number of contracts on the same side of the market that can be exercised within five consecutive business days.

c. Trading and Execution

An investor buys or sells equity options through a brokerage firm with whom he or she has an account. The customer specifies the required parameters discussed above, and the broker sends the order by phone or by computer to a central communications area on the floor of the exchange where the option is traded. From there the order is conveyed to a **floor broker** of the firm. If the brokerage firm does not employ its own floor brokers, then the order is given to an independent or to the floor broker of another firm.

The floor broker is a member of the exchange or is said to have a seat on the exchange, which means that he or she is allowed to occupy the floor and trade with other members. The floor broker is not permitted to buy or sell for his or her own account, but may only execute orders for customers.

Upon receipt of the order, the floor broker goes to the area of the exchange floor, or pit, where the option is traded. There the broker may execute the trade with another floor broker, with a market maker, or with an order book official.

A **market maker** is a member of the exchange who is required to maintain an inventory of certain options and to buy and sell from that inventory. Market makers can only buy and sell for their own accounts and are not permitted to execute customer orders. Usually, a given option is assigned to more than one market maker.

The market maker is required to quote both a **bid price**, the highest price at which he or she is willing to buy, and an **ask price**, the lowest price at which he or she is willing to sell. However, the floor broker who requests the quote does not have to reveal whether the order is a buy or a sell. This system of public auction via open outcry enables rapid and efficient price discovery, insures that orders can usually be executed at some price, and provides the required market liquidity.

The third primary player on the equity options exchange floor is the **order book official**. If a floor broker is trying to fill a buy limit order at $10, but the lowest current ask price among the market makers is $11, then the order will not be executed. The limit order is then conveyed to the order book official who is employed by the exchange and who may only execute customer orders. The order book official enters the limit order into a computer where it can be viewed by other members of the exchange. The order is then executed when the limit price is quoted by a market maker.

The prices at which options are quoted and traded on the exchange floor must be integral multiples of some minimum value that is set by the exchange. The minimum price fluctuation or "tick size" of contracts traded at U.S. exchanges is 1/16 (or \$6.25 per contract) for options whose price is less than \$3.00 and 1/8 (or \$12.50 per contract) for all other options.

The system just described is the one in place at the CBOE. The American Stock Exchange (AMEX) and the Philadelphia Stock Exchange (PHLX) use a slightly different system. At these exchanges, specialists serve as both the market makers and the order book officials. As market makers, they fulfill the dealer function by maintaining inventory and trading for their own accounts. As order book officials they fulfill the broker function by accepting and executing the customer limit orders. However, unlike an order book official at the CBOE, the specialist is not required to show the limit orders to other members. Another feature of the specialist system is the presence of other floor traders who trade for themselves and attempt to profit from buying and selling mispriced options.

Some of the major non-U.S. options exchanges, such as the Amsterdam Options Exchange (AEX Options) and the Australian Stock Exchange, Derivatives (ASXD), employ similar open outcry auction trading systems. However, other major foreign options exchanges, such as the Swiss Options and Financial Futures Exchange (SOFFEX), the Deutsche Terminborse (DTB), OM Stockholm, and the Marche des Options Negociables de Paris (MONEP), use electronic screen-based systems.

Electronic systems replace open outcry in an exchange floor pit with remote computer order entry, routing, and matching. Screen-based trading is cheaper than open outcry because the systems do not require a large building to house trading floors and are much less labor intensive. Since all trade data originate in a computer, the recording, processing, and dissemination of trade related information is easier and more efficient. However, the systems originally provided less liquidity and information because of the absence of market makers and specialists who were willing to take either side of a trade.

The use of computer based trading systems has grown rapidly over the last few years and is likely to continue to grow. New derivative exchanges will probably use them exclusively because they provide an effective and efficient way to begin operations. American exchanges are likely to continue with open outcry for the foreseeable future, but they will continue developing electronic trading systems to extend the trading day and to test new products.

d. Clearing, Settlement, and the Option Clearing Corporation (OCC)

The creation of the clearing house provided an intermediate organization that, in effect, steps between every pair of traders, buys from the seller, then sells to the buyer, and automatically becomes the counterparty to every trade. The clearing house thus provides the liquidity required for an active secondary market because a buyer or seller who wishes to close out his or options position does not have to find and trade with the original party.

The clearing house also encourages and facilitates trading among strangers because buyers and sellers do not have to worry about the creditworthiness of their trading partners. As the opposite side of every trade, the clearing house guarantees the terms of all contracts and thereby transfers credit risk from the market participants to the clearing house members.

The U. S. equity options market is served by a single clearing house, the Options Clearing Corporation (OCC). The OCC is a company that is equally owned by the four U.S. exchanges that list individual stock options: the AMEX, the CBOE, the PHLX, and the Pacific Stock Exchange (PCX).

After a trade is executed on the exchange floor, the terms of the trade must be reported to the OCC, and the trade must be settled in cash. The buyer and seller on the floor first confirm the trade with the originating brokerage firms. If an originating firm is a clearing firm, then it reports the trade details directly to the OCC. An **options clearing firm** is a broker/dealer or securities firm that is a member of the OCC. To become a member of the OCC, a firm must also be a member of one of the exchanges that owns the OCC. In addition, the firm must meet minimum capital requirements and must make a deposit to a clearing fund that is used to guarantee the financial obligations of any options issued by the OCC. Only clearing firms can submit trades to the OCC for final clearing.

Upon receipt of the trade details, the OCC compares the data from both sides of the trade, and if the information matches, then the trade becomes official. The OCC becomes both the buyer to the writer and the writer to the buyer, and any link between the original buyer and writer is terminated. The clearing member settles the transaction in cash the following day, and the option is issued at the same time. This procedure also allows a buyer or writer to easily close out a position at any time without having to trade with the original counterparty. An options owner needs only to write the same contract to anyone willing to buy and when the trade clears, the offsetting transaction enters the customer's account with the OCC, and both trades are canceled.

e. Exercise, Assignment, and Delivery

All individual stock options listed on U.S. exchanges are American style and can therefore be exercised on any business day before the expiration day. Only the owner of an option has the right to exercise. Upon exercise, the writer is assigned the obligation of fulfilling the terms of the contract. This requires delivery of shares of stock in the case of a call, or payment of the strike price in cash in the case of a put. The exerciser then becomes obligated to pay the strike price of the long call for the delivered stock, or to deliver the shares of the stock that underlies the long put.

An investor who wishes to exercise an option must first inform a broker of his or her intent. If not an OCC clearing member, this broker must submit the request to a member broker. The clearing member then submits an exercise notice to the OCC that must be received between 10:00 a.m. and 8:00 p.m. Eastern Time (ET) on any business day prior to the last trading day. Notices not submitted by the last trading day can then only be submitted before 5:00 p.m. on the expiration day. Even though the OCC does not accept exercise notices on the last trading day, a customer can still submit exercise instructions to the clearing member on that day until 5:30 p.m. ET.

The OCC automatically exercises all options that expire 3/4 of a point or more in the money unless instructed otherwise. Options that expire only 1/4 of a point or more in the money are also automatically exercised if they are owned by a market maker or an exchange member.

When the OCC accepts the exercise notice, the option is randomly assigned to one or more clearing members who have a short position in the same option. The assigned member is notified on the first business day after the exercise notice is received by the OCC. The clearing member then assigns one of its customers who is short the option. This assignment is made either randomly or on a first-in/first-out basis. Once assigned, the customer is prohibited from closing out the short position with an offsetting purchase.

Physical delivery of the underlying stock shares must be made by 1:00 p.m. ET on the third business day after OCC acceptance of the exercise notice. For a call option, the assigned clearing member firm delivers the underlying stock to the exercising clearing member firm, who in turn delivers the strike price of the call in cash. For a put option, the assigned clearing member firm delivers the strike price of the put in cash to the exercising clearing member firm, who in turn delivers the underlying stock.

f. Commissions and Transaction Costs

Options brokers charge commissions for performing services such as executing customer orders, maintaining accounts, and providing confirmations and trade reports. Customers pay commissions on options transactions when:

- Options are bought or sold to establish an initial position,
- Options are bought or sold to close out an existing position, and
- Options are exercised. A call or put exerciser must pay commissions on the stock that is purchased or sold at the strike price. Likewise, the writer of the call or put must pay commissions on the stock that is sold or purchased at the strike price.

No additional commissions are paid if an option is allowed to expire.

The commissions that institutional investors pay to brokers for options transactions are approximately $1 to $3 per contract, but are negotiable and vary from broker to broker. They depend on the relationship between the customer and the broker and upon the size of the transaction, with the percentage cost decreasing as the value of the trade increases. Retail investors who trade through discount brokers also pay lower percent commissions as the total value of the trade increases, but retail commissions are usually not negotiable. Typical retail commissions range from about $25 for a single contract, to $8 per contract for 10 contracts, to $5 per contract for 20 or more contracts.

Another transaction cost is the bid/ask spread. Market makers and specialists on the floors of the options exchanges are required to buy and sell options from their own inventory. In return for the risk that they bear for performing this service, they buy at a lower price (the bid) than the price at which they sell (the ask). This difference is called the bid/ask spread.

The maximum allowable spreads are set by the exchanges and depend upon the option price as follows:

Option Price	Maximum Spread
Less than $0.50	1/4
$0.50 or more but less than $10	1/2
$10 or more but less than $20	3/4
$20 or more	1

Actual spreads paid by customers are often lower than the maximum because of competition among market makers. Spreads are also a function of supply and demand and increase as the trade size and the need for immediate execution increase. Demand generally decreases and the spread increases as the time to expiration increases and as the option becomes more in-the-money.

Investors who use options as stock substitutes or to hedge existing stock portfolios incur roughly the same transaction costs as investors who hold the equivalent stock positions. However, some complex options strategies known as spreads involve initiating and reversing positions in up to four different options. Such a strategy would involve paying eight commissions and four bid/ask spreads which could consume most of the potential profits, especially for the retail investor.

g. Margin

When stocks are bought "on margin," the buyer deposits at least 50% of the purchase price into a margin account and borrows the balance from a broker. When stocks are sold short, the seller deposits at least 50% of the selling price plus the entire proceeds of the sale into the account. Margin for stock transactions is therefore a minimum 50% down payment on the value of the stock plus a loan.

Margin for options transactions is the cash or cash equivalent that the writer of an option must deposit with a broker as collateral to insure that he or she fulfills the obligation to deliver stock or cash if the option is assigned. Margin in the options market is then more of a performance bond that protects the brokerage firm and clearing member against loss should the terms of the contract not be fulfilled. Minimum margin requirements are set by the Federal Reserve Board and by the options self-regulatory agencies. The brokerage firms who are clearing members of the OCC stand to lose the most if a customer defaults so they often request more than the minimum margin.

The rules for determining margin requirements are complex and are based upon the overall risk of an options position or a position that combines options, stocks, and futures. The margin requirement is determined using statistical models and is designed to be large enough to ensure that the decline in the value of a position over seven business days exceeds the margin in only 5% of the possible outcomes. Margin requirements change frequently because the risk parameters used to compute them change, and margin requirements differ from one brokerage firm to another. Therefore, it is difficult to list a set of margin rules that applies to every customer and every position. However, the following are the minimum initial margin requirements for some of the most common options strategies. These strategies are discussed in more detail in Chapter Five.

1) Long Calls and Puts

The purchase price of a call or put must be paid in full. Buying on margin and borrowing part of the purchase price is not permitted.

2) Written Calls and Puts

The required margin is the greater of:

- 100% of the proceeds of the sale plus 20% of the value of the underlying stock minus the amount by which the option is out of the money, or
- 100% of the proceeds of the sale plus 10% of the value of the underlying stock.

The proceeds of the sale may be applied to the initial margin requirement.

3) Long Stock Plus Written Call (Covered Call)

The required margin is 50% of the value of the underlying stock. No additional margin is required for the written call because the loss when the stock price increases is offset by the gain from the long stock position. The proceeds of the call sale may be applied to the stock margin.

4) Short Stock Plus Written Put

The required margin equals the proceeds of the stock sale plus 50% of the value of the underlying stock. No additional margin is required for the written put because its loss when the stock price decreases is offset by the gain from the short stock position. The proceeds of the put sale may be applied to the stock margin.

5) Call or Put Spread

A spread is a long position in a call or put and a short position in another call or put on the same underlying stock but with a different strike price and/or expiration date.

The margin requirement for a call spread is the difference between the strike price of the long call and the strike price of the written call multiplied by the contract unit. If this quantity is zero or less, then the margin is simply the cost of the long call. In both cases the proceeds from the written call may be applied to the margin.

The margin requirement for a put spread is the difference between the strike price of the written put and the strike price of the long put multiplied by the contract unit. If this quantity is zero or less, then the margin is simply the cost of the long put. In both cases, the proceeds from the written put may be applied to the margin.

6) Call or Put Combination

A combination is an all-long or all-short position in both the calls and puts of the same underlying stock.

The margin requirement for a long combination (long call plus long put) is the entire cost of both options.

The margin requirement for a short combination (written call plus written put) is the individual requirement on the written call or put—whichever is greater---plus the sale proceeds of the other option. The sale proceeds of both options may be applied to the initial margin requirement.

The margin requirements for other, more complex positions that involve many options and the stock are found by decomposing the position into simple spreads, combinations, hedges, and residual options and aggregating the margin of the components.

Maintenance margin is the same as initial margin for options. Margin requirements are computed every day using the rules described above except that the current stock and option prices are used instead of the purchase or sale prices. Then the account is marked to market, that is, if the proceeds in the account exceed the required margin, the investor may withdraw the surplus. If the proceeds are less than the required margin, the investor receives a margin call and must deposit the shortfall.

h. Taxation

Like commissions and margin, taxes are seldom considered when analyzing the profit and loss characteristics of options strategies. However, taxes can also have a significant impact on the returns of options transactions for non-exempt investors. The purpose of this section is to outline some of the parameters which affect the tax treatment of equity options. Since the tax laws in general and the tax treatment of options in particular change frequently, no attempt is made to document the current tax status. However, since tax considerations are important to any options transaction, investors should consult their tax advisors to determine the exact effects on their individual situations.

1) Investor Tax Status

The most important parameter that affects the tax treatment of equity options is the tax status of the options investor. U.S. Pension plans that qualify for tax exempt status under the Employee Retirement Income Security Act (ERISA) of 1974 and other tax exempt entities such as religious organizations and charitable and educational foundations generally pay no taxes on the gains from options or any other securities. Other entities such as individuals and corporations are taxed on the gains from options transactions.

2) Capital Gains and Losses

Another important factor that affects the taxation of the proceeds of options transactions is the definition and treatment of capital gains and losses in the general tax code. Some of the important considerations include the following:

- The difference in the rate at which short-term and long-term capital gains are taxed,
- The length of the holding period required to qualify a capital gain as long term,
- The manner in which capital losses can be used to offset capital gains, and
- The amount of capital losses that can be used to offset capital gains during any one tax year.

3) Tax Laws Specific to Options

A third factor that affects the tax treatment of options transactions is the definition and treatment of gains and losses from options contracts in the specific tax code. Some of the important provisions include the following:

- The treatment of profits as income or capital gains,
- The treatment of profits as a function of the underlying security. For example, historically the tax treatment of profits from stock options, stock index options, and options on stock index futures has not been the same.
- The option position. For example, the tax treatment of uncovered options is usually different from the tax treatment of spreads and combinations.

The provisions of the general and options specific tax code can affect not only the profits of an options strategy, but also the choice of the strategy itself. For example, as the tax laws have changed since the introduction of listed equity options in 1973, strategies using options have been devised and used to convert income into lower taxed capital gains, to time the recognition of gains and losses, and to convert short-term capital gains into long-term capital gains.

Some recent U.S. tax legislation has given mutual fund managers an additional incentive for using stock options and stock index options. A mutual fund as a regulated investment company is permitted to distribute income to its shareholders without first being taxed as a corporation. However, since 1936 the "short-short" rule or "30%" rule revoked mutual fund status and disallowed this pass-through advantage if more than 30% of a fund’s gross profits before deduction of losses was derived from the sale or disposition of securities that were held for less than 90 days. Mutual fund managers were thus reluctant to use short term options or futures for fear of losing as much as 35% of their portfolio gains to the corporate income tax. The short-short rule was repealed on August 5, 1997 by the Taxpayer Relief Act thereby freeing fund managers from this potential tax liability.

i. Regulatory Environment

The trading of options and other U.S. securities is regulated by the Federal Government. Regulation is designed to insure fair and orderly operation of the market, to encourage participation by providing assurances that the market will not be manipulated, and to guarantee that contract obligations are met.

The organization with the primary responsibility for overseeing the options market is the Securities and Exchange Commission (SEC), which was authorized to regulate options trading by the Investment Securities Act of 1934. The SEC also regulates the trading of all U.S. stocks and bonds, bond options, bond index options, stock index options, and foreign currency options that are traded on stock and bond exchanges. Futures contracts, options on futures, and options on physical commodities are regulated by the Commodity Futures Trading Commission (CFTC).

The primary responsibilities of the SEC are to grant permission to the exchanges to list new options, and to approve market makers. However, most of the actual regulation is performed by the exchanges themselves and by the OCC. These organizations draft and adopt their own rules, which must be filed with and approved by the SEC.

The primary issue addressed by regulation is customer suitability. The fundamental rule is that options are not suitable for every investor and parameters such as net worth, income, investment experience, proposed options strategy, and relationship with the broker-dealer should be carefully considered before recommending the addition of options to customer portfolios. A related area of regulation is the distribution of sales material. Specific rules exist that stipulate how sales material regarding options can be distributed to customers and who is required to approve such distribution. A final area of regulation is the actual trading of options by the various floor participants.

B. OTC Options

Despite the popularity and growth of the listed options market, OTC options remain an important investment vehicle, especially on fixed income securities and foreign currencies. The primary participants in the OTC equity options market are financial institutions and corporations. Modern OTC equity options, like those that preceded listed options, are contracts whose specific terms are privately negotiated and agreed upon by the buyer and seller. These customized calls and puts are popular because the standardized features of exchange-traded options often do not meet the needs of large institutional investors. For example, OTC options allow investors to access or manage the risk of equity markets that do not underlie listed index options. Certain institutions can trade much larger size in the OTC market than they can in the listed market because of position limits and liquidity constraints that exist in the latter. Also, nonstandard features can be built into options, which produce profit and loss scenarios that are much more complicated than those of standard calls and puts. Options with such features are called exotic options and are discussed in more detail in Chapter Six.

In response to the growing demand for options with a wider variety of terms and features, FLEX™ Options (FLexible EXchange listed options) were introduced by the CBOE in 1993 and by the AMEX in 1996. FLEX options offer large investors the ability to customize the terms of an option contract. They are available on both individual stocks and indexes. FLEX options have larger position limits than conventional options and can have either American or European exercise style. Their expiration date can be any business day up to three years from the trade date except the third Friday of the month. FLEX calls are struck at the same intervals as conventional equity options. FLEX puts are struck at 1/8 intervals and can even be struck as a percentage of the underlying stock price. FLEX options are also guaranteed by the OCC so buyers and sellers are not subject to credit risk like their counterparts in the OTC market.

Chapter Three

Option Pricing

In this chapter we identify and discuss the variables that determine the value or price of an equity option. Our goal is to impart without mathematical rigor some intuitive understanding of how these variables affect option prices. The prices of options have natural boundaries that limit the minimum and maximum values that they can attain in the marketplace. In equilibrium, the price of an option depends not only on the contract terms such as strike price and time to expiration, but also upon conditions that prevail in the market such as the volatility of the underlying stock price and the term structure of interest rates. The following discussion pertains only to simple call and put options.

A. The Variables That Determine Option Prices

The price of an equity option depends upon the following six variables:

- The price of the underlying stock, S
- The strike or exercise price of the option, K
- The volatility of the underlying stock, σ
- The riskless interest rate, r
- The time remaining to option expiration, t
- The dividends paid by the underlying stock, D.

In the remainder of this chapter we will qualitatively discuss the effects that each of these variables has upon the option price. To simplify the discussion, we will consider only European style options. The effects of American exercise will be discussed in a separate section.

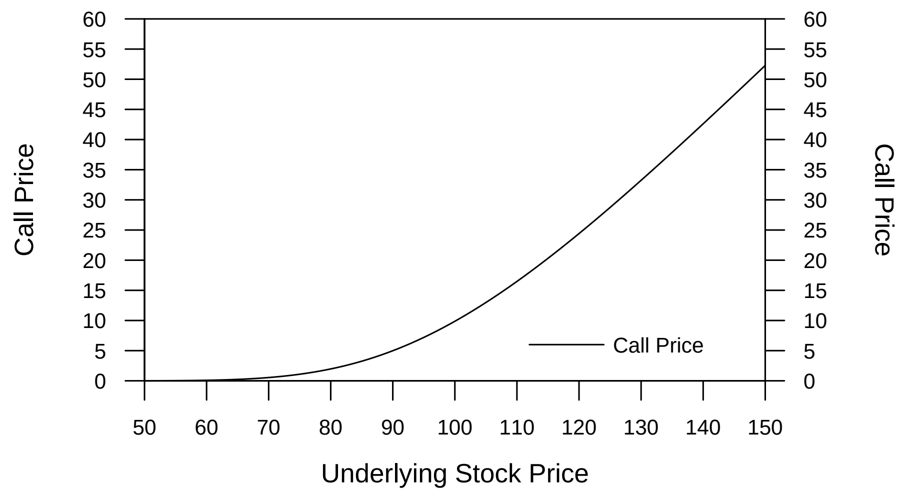
1. The Price of the Underlying Stock

Figures 3 and 4 show how the prices of a European call and put option vary with the underlying stock price. The options have the following parameters:

- Strike Price = 100
- Time Remaining to Expiration = 150 Days
- Volatility = 35% per year
- Interest Rate = 5% per year
- Dividends = 0

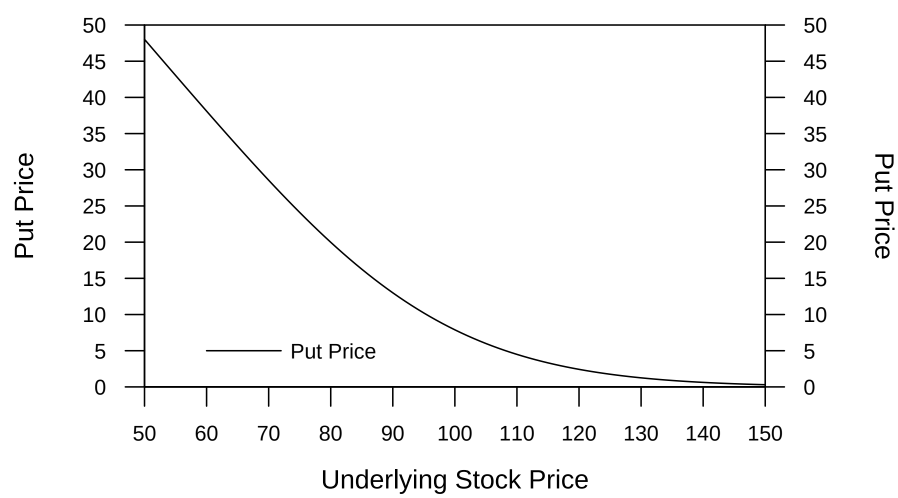
We will use these same parameters in all of the examples in this chapter, unless noted otherwise.

Figure 3. Call Price versus Underlying Stock Price



Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 4. Put Price versus Underlying Stock Price



Source: Smith Barney Inc./Salomon Brothers Inc.

Note from Figure 3 that the call price *increases* directly as the underlying stock price *increases.* Furthermore, the call price increases at a faster rate as the stock price increases, and when the stock price is very large, the call price increases almost dollar for dollar with the stock price. Figure 4 shows that the put price and the rate of increase of the put price both *increase* in the same manner as the call, but as the underlying stock price *decreases*.

If the underlying stock price S is *greater than* the strike price K of a call option, then the call is said to be **in-the-money** (**ITM**). The term derives from the fact that an owner or holder of an ITM call option can exercise it and buy the stock for K, immediately sell the stock for the higher price S, and realize an immediate profit of (S - K). If the underlying stock price is *equal* to the strike price, then the call is said to be **at-the-money (ATM),** and if the stock price is *less than* the strike price, the call is said to be **out-of-the money (OTM)**. Similarly, a put option is ITM if the stock price is *less than* the strike price. In this case, the owner or holder of the ITM put option can buy the stock for S, exercise the put, sell the stock for the higher price K, and realize an immediate profit of (K - S). A put is ATM if the stock price *equals* the strike, and is OTM if the stock price is *greater than* the strike.

Intuitively, the price of a call *increases* as the underlying stock price *increases* because the chances of the stock price being above the strike price and the call being ITM at expiration increase if the current stock price is already above the strike. Similarly, the price of a put *increases* as the underlying stock price *decreases* because the chances of the stock price being below the strike price and the put being ITM at expiration increase if the current stock price is already below the strike.

2. The Strike Price of the Option

Increasing the strike price of a call option has the same effect on the call price as *decreasing* the stock price, i.e., the call price *decreases*. Similarly, *increasing* the strike price of a put option has the same effect as *decreasing* the stock price, i.e., the put price *increases*. The important variable is the difference between the stock price and the strike price, (S - K). When (S - K) is zero, an option is ATM and its price corresponds to that shown in Figures 3 or 4 when the stock price is 100. When (S - K) is, say, 25, a call is deep ITM, a put is far OTM, and the option prices correspond to those shown in Figures 3 and 4 when the stock price is 125.

Intuitively, the price of a call option *increases* as the strike price *decreases* because the price at which the holder can buy the stock at expiration decreases as the strike price decreases. Similarly, the price of a put option *increases* as the strike price *increases* because the price at which the holder can sell the stock at expiration increases as the strike price increases.

The price or value of an option can be separated into two components, the **intrinsic value** and the **time value**. The intrinsic value is a function of the stock price and the strike price, and the time value is a function of the remaining pricing variables. The intrinsic value is simply the amount by which the option is in the money which is (S - K) for a call and (K - S) for a put. An ITM option has both intrinsic value and time value, while an ATM or OTM option has only time value.

The time value also has two components. The first of these is the **leverage value** which is a function of both the riskless interest rate and the time to expiration. The owner of a call option does not have to pay the strike price for the stock until the option is exercised. The leverage value of the call is then the interest received over the life of the option from investing the present value of the strike price at the riskless rate. Similarly, the owner of a put option does not receive the strike price for the stock until the option is exercised. So the leverage value of a put is negative because the owner forfeits interest over the life of the option by not being able to invest the present value of the strike price at the riskless rate. The leverage value therefore increases the price of a call and decreases the price of a put.

The second component of time value is the **volatility value** which is a function of both the price volatility of the underlying stock and the time to expiration. As we discuss in more detail in the next section, the volatility of the underlying stock is a measure of the price range that the stock is likely to achieve during the option's lifetime. As the volatility increases and this likely price range widens, then the option has a greater chance of expiring ITM and its value increases.

The components of option value are summarized in the following expression:

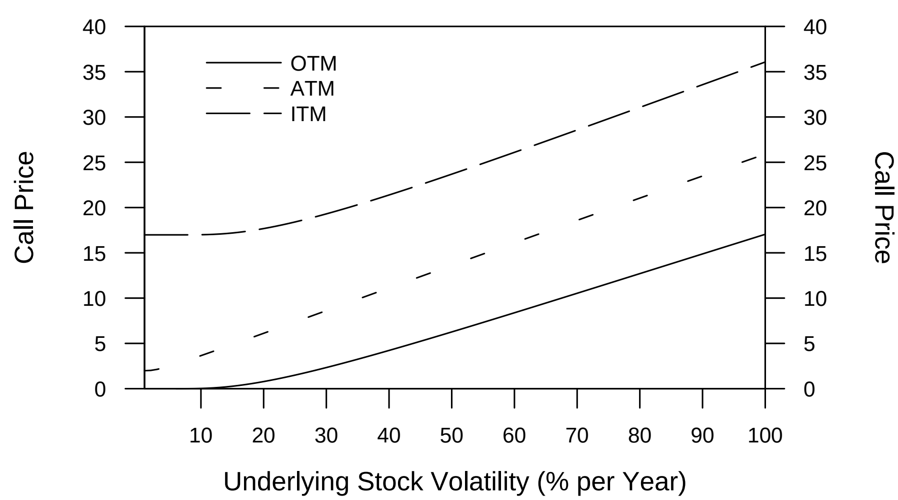
$$\textit{Option Value} = \textit{Intrinsic Value} + \textit{Leverage Value} + \textit{Volatility Value}$$

The variables that affect the volatility and leverage components are discussed in the following sections.

3. The Volatility of the Underlying Stock

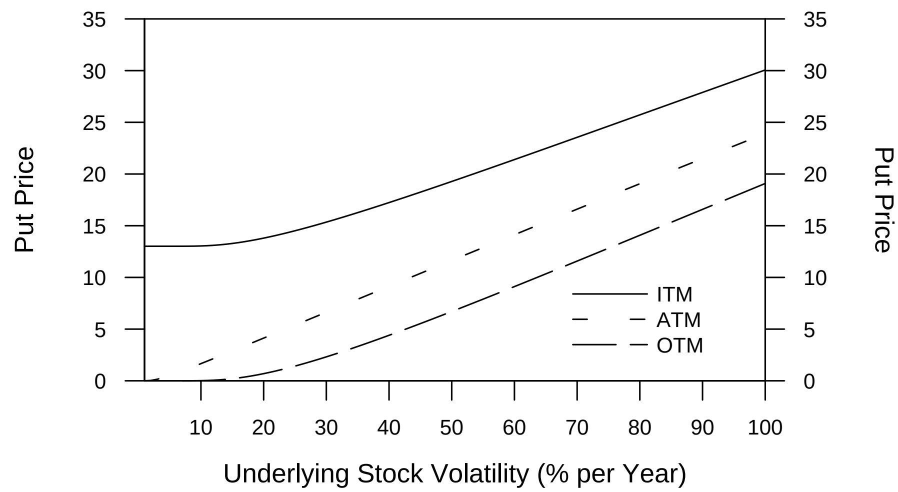
Figures 5 and 6 show how the prices of OTM, ATM, and ITM call and put options vary with the volatility of the underlying stock. The strike price is 100, and the underlying stock prices for the OTM, ATM, and ITM calls are 85, 100, and 115, respectively, and for the puts are 115, 100, and 85.

Figure 5. Call Price versus Underlying Stock Volatility



Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 6. Put Price versus Underlying Stock Volatility



Source: Smith Barney Inc./Salomon Brothers Inc.

Note from Figures 5 and 6 that both call and put prices increase as the volatility increases. The relationships are nearly linear, especially at higher volatilities, and the slopes are very similar for OTM, ATM, and ITM options.

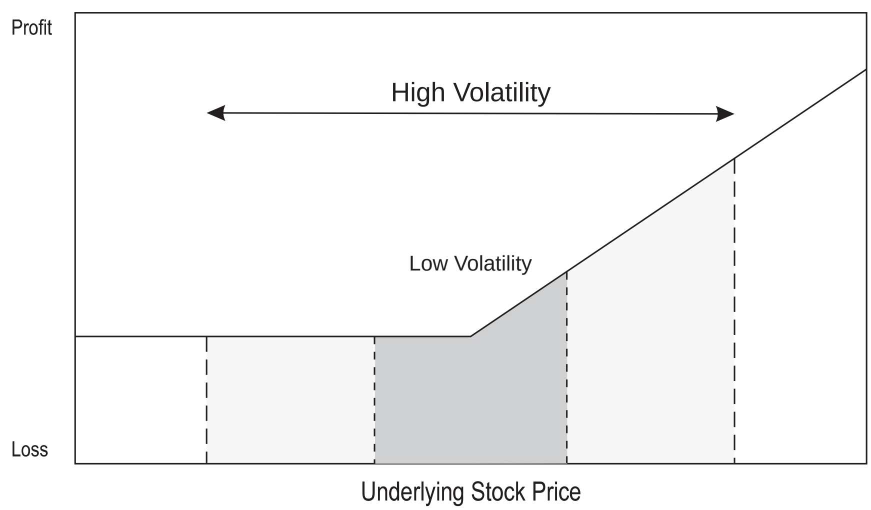
As mentioned earlier, volatility is a measure of the price range that a stock is likely to attain over some time period. As the volatility increases, the stock price has a greater chance of moving farther in either direction, which increases the value of both calls and puts because they in turn have a greater chance of expiring ITM. Volatility and the time to expiration work together to affect the price of an option. High volatility increases the size of the possible price change, and a long time to expiration increases the time available to achieve that change.

Much of modern finance and options pricing theory revolves around the concept of volatility or risk. The common measure of volatility *is the standard deviation of the future returns* of an asset or a portfolio of assets. Modern finance theory teaches that the expected returns of a thoroughly diversified portfolio increase as the portfolio volatility increases. Therefore, in equilibrium, a riskier or more volatile portfolio should sell at a lower price to compensate for the higher risk. Essentially, greater risk and volatility result in a higher expected return that is manifested by a lower initial asset price.

With options, however, the volatility versus price relationship is opposite to that of the underlying asset. That is, the *greater the volatility the more valuable the option*. As the volatility increases the stock price becomes more variable and can undergo larger moves in either direction. However, the option feature protects the owner from large moves in the downside direction so that the payoff as a function of stock price is not symmetric. This inherent asymmetry of the payoff profile results in a higher option value for a higher level of asset volatility.

Consider the standard call option payoff diagram depicted in Figure 7 which shows the value of a call versus the underlying stock price at expiration The inner pair of vertical lines represents a low volatility stock with a narrow possible price range. The outer pair of vertical lines represents a higher volatility stock with a wider possible price range. The upside payoff region of the low volatility stock is truncated. The likelihood of making or losing money is roughly equal, and the expected return is close to zero. However, we see that for the high volatility stock the accessible area to the right under the payoff line is much larger as is the expected return. Increasing the volatility increases the magnitude of the potential payoff to the option holder without increasing the potential loss. In equilibrium, the premium should be higher for the option on the more volatile asset because the overall expected return has increased with volatility.

Figure 7. Payoff Diagram for a Call Option on a High and Low Volatility Stock

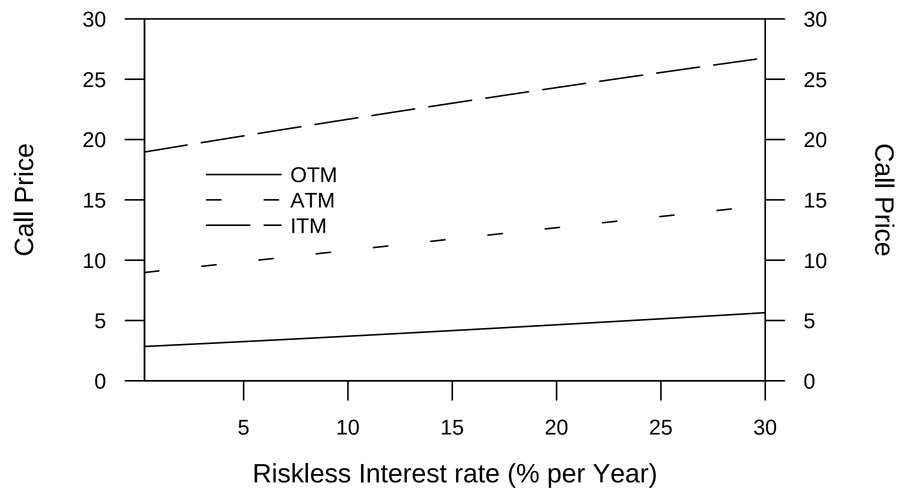


Source: Smith Barney Inc./Salomon Brothers Inc.

4. The Riskless Interest Rate

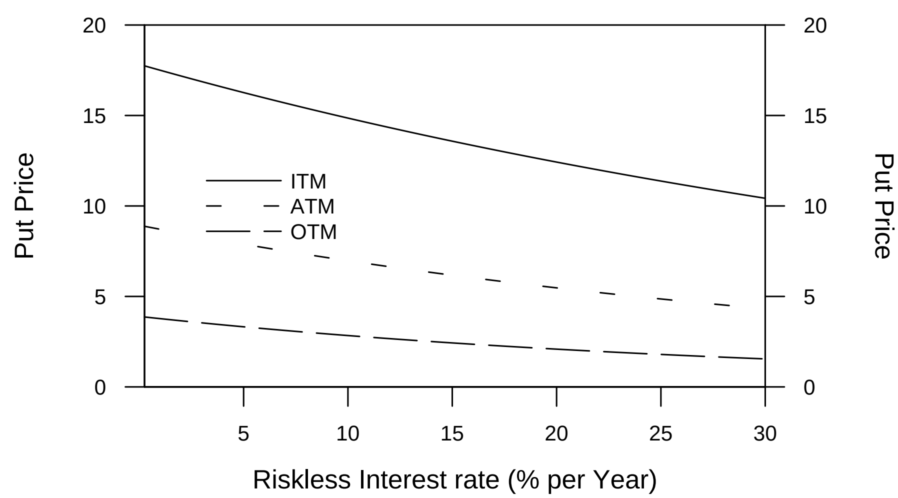
Figures 8 and 9 show how the prices of a call and a put vary with the riskless interest rate for OTM, ATM, and ITM options. The strike price is 100 and the underlying stock prices are 85,100, and 115.

Figure 8. Call Price versus Riskless Interest Rate



Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 9. Put Price versus Riskless Interest Rate



Source: Smith Barney Inc./Salomon Brothers Inc.

Note from Figures 8 and 9 that the call price *increases* and the put price *decreases* as the interest rate *increases*. The relationships are nearly linear and the price changes are small for a given change in the interest rate.

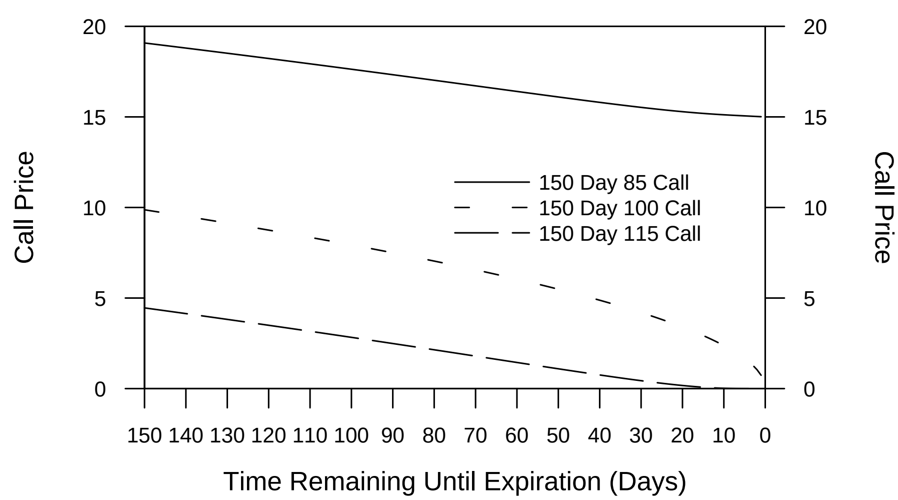
As mentioned previously, the leverage value of an option is one component of the time value. The leverage value is simply the interest earned, in the case of a call, or forfeited, in the case of a put, on the present value of the strike price. Therefore, as the interest rate increases, the leverage value increases which in turn increases the price of a call and decreases the price of a put.

The relationship between the interest rate and the option price can also be discussed in terms of the effect of the interest rate on the demand for the options. When interest rates are high, investors prefer to buy call options instead of the underlying stock because they can invest the difference between the stock price and the call price in high yielding fixed income securities. Therefore, high rates increase the demand for calls, which increases their price. Similarly, when interest rates are high, investors prefer to sell the underlying stock instead of buying put options because they can earn high interest on the proceeds of the stock sale. So high rates decrease the demand for puts which decreases their price.

5. The Time Remaining to Option Expiration

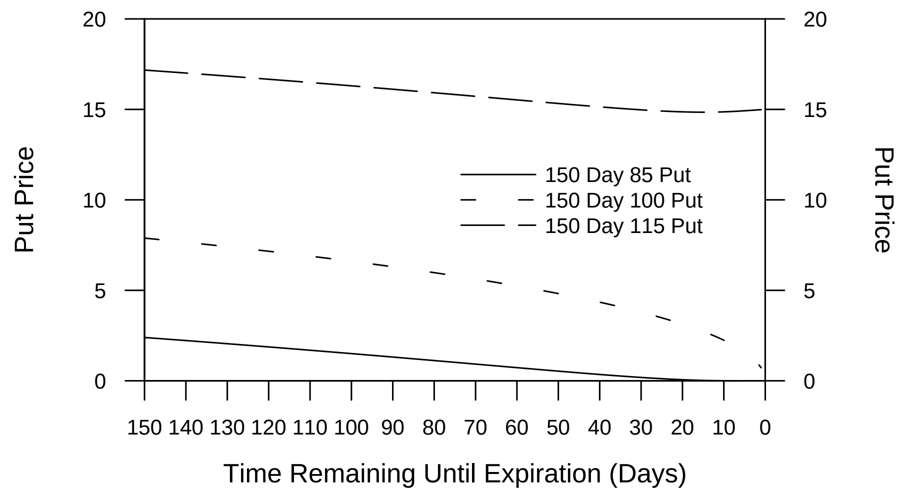
Figures 10 and 11 show how the prices of OTM, ATM, and ITM call and put options vary with the time remaining to option expiration.

Figure 10. Call Price versus Time Remaining to Expiration



Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 11. Put Price versus Time Remaining to Expiration



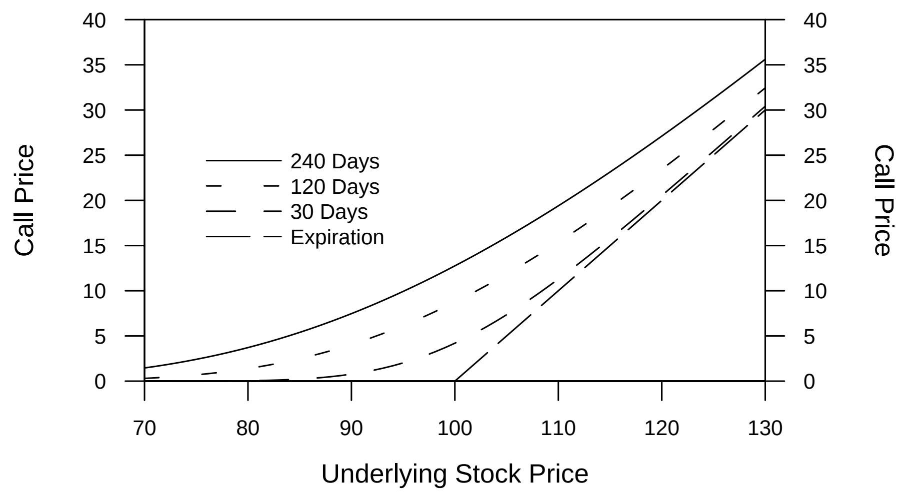
Source: Smith Barney Inc./Salomon Brothers Inc.

Note from Figures 10 and 11 that the prices of both calls and puts *decrease* as the time to expiration *decreases*. This loss in value as expiration approaches is known as the **time decay** of an option. The time decay of ATM calls and puts becomes very nonlinear as the options approach expiration with nearly 25% of the call time decay and 30% of the put time decay occurring in the last 10 days of the option's life. The time decay of OTM and ITM calls and puts is much more linear. OTM options have only time value which decays to zero at expiration. Since only the time value decays, the prices of ITM options decrease to their intrinsic value at expiration.

In Chapter Five we discuss the effects of time decay on the profit and loss of numerous options strategies. Figures 10 and 11 show that all options are "wasting assets" because they decrease in value as time passes and nothing else occurs. Therefore, a position that consists only of long options will decrease in value over time, all else equal. Furthermore, because of the rapid time decay near expiration, buyers of ATM options should use longer term options whenever possible, and sellers of ATM options should use shorter term options whenever possible.

Figure 12 depicts the time decay of a call option in a different manner. The figure shows the price of a call versus the underlying stock price at three different times to expiration and at expiration. The vertical decrease in the call price for a given stock price is a measure of the time decay. Again, note that the maximum time decay during the last 30 days of the option's life occurs when the underlying stock price is $100 and the call is ATM.

Figure 12. Call Price versus Underlying Stock Price for Different Times to Expiration



Source: Smith Barney Inc./Salomon Brothers Inc.

As mentioned previously, time works with both the volatility and the interest rate to affect an option's price. High volatility increases the size of a possible price change, and a long time to expiration increases the amount of time available to achieve that change. So an increase in time to expiration increases the volatility value of both a call and a put. A high interest rate increases the amount of interest that a call buyer earns and a put buyer forfeits, and thereby increases the value of a call and decreases the value of a put. A longer time to expiration increases this interest and affects the option prices in the same manner. So an increase in the time to expiration increases the leverage value of a call and decreases the leverage value of a put. Also, if two options are identical except for their times to expiration, the longer term option can still be exercised at a profit after the shorter term option has expired. This additional property adds value to the longer term option.

6. Dividends

When a stock goes ex-dividend, the stock price (usuallly) decreases by the amount of the dividend. Therefore, the price of a call decreases and the price of a put increases when the underlying stock pays a dividend. Viewed another way, since the owner of a call does not own the stock and does not receive the dividend, the call becomes less valuable. Similarly, since a put owner has not sold the stock and does not forfeit the dividend, the put becomes more valuable.

7. American Versus European Exercise

We now consider the effect of exercise style on the option price. Consider first an American call and a European call with identical parameters on a stock that does not pay dividends. Since the American call gives its holder an additional right, namely the right to exercise the option early, then its value must always be at least as great as, and possibly greater than, the price of the European call.

Now, can we estimate the value of the right to exercise an American option early? As discussed previously, an ITM call option has $(S-K)$ worth of intrinsic value plus some time value. If the option is exercised, the holder realizes a profit of $(S-K)$. However, if the option is sold, the holder receives $(S-K+\textit{time value})$. Therefore, an American call should never be exercised early because it is always more profitable to sell it. So the right to early exercise is worthless since it will never be used. Therefore, an American call and a European call with identical parameters on a stock that does not pay dividends have the same value.

Now assume that the underlying stock *does* pay a dividend. If the American call is ITM, then immediately before the stock goes ex-dividend the option is worth $(S-K+\textit{time value})$ and can be exercised for $(S-K)$. Immediately after the stock goes ex-dividend the stock price is reduced by D, the present value of the dividend, and the option is worth only $(S-D-K+\textit{time value})$. Therefore, if

$$(S-K)>(S-D-K+\textit{time value})$$

or, if

$$D>\textit{time value}$$

then it is more profitable to exercise the option immediately before the stock goes ex-dividend. Therefore, when the underlying stock pays a dividend, the right to exercise an American call option early can have value, and so its price is greater than that of a European call with identical parameters. Note that the time value in the first condition above is equal to the present value of the interest earned on the strike price plus the volatility value.

So, to summarize, the price of an American call option on a stock that *does not* pay a dividend *is equal to* the price of an identical European call. The price of an American call option on a stock that *does* pay a dividend *is greater than* the price of an identical European call. Furthermore, the difference in price increases as the present value of the dividend increases and as the time value of the option decreases. The latter occurs as the interest rate, time to expiration, and volatility decrease and as the call becomes more ITM.

Now consider an American put and a European put with identical parameters on a stock that does not pay dividends. An ITM put option has (K - S) worth of intrinsic value plus some time value. However, the time value of a put is less than that of an identical call because the leverage component consists of foregone interest and is negative. Therefore, it is possible for the intrinsic value to exceed the put value at any time prior to expiration. Then it is more profitable to exercise the put early. That is, an American put should be exercised early if

$$(K - S) > (K - S - \textit{leverage value} + \textit{volatility value})$$

or, if

$$\textit{leverage value} > \textit{volatility value}$$

In this case, the right to exercise the American put option early does have value, and the price of the American put is greater than that of the European put with identical contract terms.

The leverage value of a put, like that of a call, equals the present value of the interest earned (foregone) on the strike price. Therefore, it *increases* as the interest rate and the time to expiration increase. The volatility value *decreases* as the stock price volatility and the time to expiration decrease, and as the option becomes more ITM. So the first condition above will be satisfied if the put is deep ITM and interest rates are high.

When an option's price is roughly equal to its intrinsic value, the option is said to be trading *at parity*. Since the time value of a call option is always positive, then an ITM call will always trade above parity unless a dividend payment that is greater than the time value becomes reflected in the option price before the stock price. A call will trade at parity when it is ITM and about to expire. However, an ITM put option can trade for less than parity at any time as long as the first condition above is satisfied.

Now consider the case where the underlying stock pays a dividend. If the American put is ITM, then immediately before the underlying stock goes ex-dividend the option is worth $(K - S + \textit{time value})$ and can be exercised for $(K - S)$. Immediately after the stock goes ex-dividend, the stock price decreases by D, the present value of the dividend, and the put value increases to $(K - S + D + \textit{time value})$. Therefore, if

$$(K - S) > (K - S + D - \textit{leverage value} + \textit{volatility value})$$

or, if

$$\textit{leverage value} > (D + \textit{volatility value})$$

then it is more profitable to exercise the American put early. So in contrast to a call option, a dividend payment makes a put option less likely to be exercised early and decreases the value of an American put relative to an identical European put.

8. Summary

The effect on European option prices of an *increase* in the values of the six underlying pricing variables is summarized in Figure 13.

Figure 13. The Effect of an Increase in the Underlying Variables on European Call and Put Prices

Variable	Call Price	Put Price
Stock Price	increases	decreases
Strike Price	decreases	increases
Stock Volatility	increases	increases
Riskless Interest Rate	increases	decreases
Time to Expiration	increases	increases
Dividends	decreases	increases

Source: Smith Barney Inc./Salomon Brothers Inc.

B. Formal Option Pricing Models

We have presented in this chapter a brief intuitive discussion of the variables that determine the values of simple call and put options. Considerable academic research exists that provides more formal and mathematical treatments of the valuation and pricing of options. One of the highlights of this research is the monumental work of Fischer Black and Myron S. Scholes who derived and published in 1973 the most famous and widely used formula for determining the prices of options.

The Black-Scholes pricing model can be derived by invoking the risk neutrality argument, which states that both risk neutral and risk averse investors will place the same value on an option if a riskless position can be established with a combination of the options and the underlying stock. Then one does not have to include a risk premium in the option price because it is already incorporated in the stock price. Black and Scholes further assumed that the price of the underlying asset evolves according to a lognormal distribution. These assumptions enable the formula to be expressed in terms of only one random state variable, the underlying stock price. The other variables that affect the option price and appear in the equation are observable and can be treated as fixed parameters.

The volatility is the only one of these observable variables that is not known with certainty so it must be estimated. Alternatively, one can observe the option price in the marketplace and then calculate the volatility from the Black-Scholes formula. This volatility inferred from the observed option price is called the **implied volatility**. For convenience, traders often quote option price levels in terms of implied volatility.

The real power of the Black-Scholes option pricing model is its ability to compute the exact value of a European style option on a stock that pays no dividends. The model permits the derivation of a relatively simple equation that is a function of only the five variables discussed in this chapter. The data for all of the figures in this chapter were generated with the simple Black-Scholes equation.

Myron Scholes and Robert C. Merton, who generalized and extended the original Black-Scholes model, were awarded the 1997 Nobel Prize in Economics for their contributions to the field of derivatives pricing. Fischer Black, who was cited in the Nobel Prize announcement, died in 1995.

Volumes of theoretical and empirical research have addressed the issues of options pricing. Much of this work developed extensions and modifications of the basic Black-Scholes framework. Today, the extended models and the power of modern computing provide researchers with the tools to easily model and price a vast array of very complex options with a myriad of complicated features.

C. Put-Call Parity

An important relationship exists between the values of a European style call and put option on the same nondividend paying stock with identical strike prices and times to expiration. This relationship is called **put-call parity** and is easily derived by considering two equivalent portfolios, A and B.

Portfolio A

Let Portfolio A consist of 1 share of ZYX stock and 1 put option on ZYX with strike price, K, and time to expiration t. At expiration the stock is worth S, and the put is either worthless if it expires OTM or ATM, or worth $(K - S)$ if it expires ITM. So at option expiration, Portfolio A is either worth S if S is greater than K, or worth $S + (K - S) = K$ if S is less than or equal to K.

Portfolio B

Let portfolio B consist of 1 call option on ZYX with strike price, K, and time to expiration, t, and a zero-coupon bond which is worth K when the call option expires. We denote the current price or present value of the bond as $PV(K)$. At expiration the bond is worth K, and the call is either worth $(S - K)$ if it expires ITM, or worthless if it expires OTM or ATM. So at option expiration, Portfolio B is either worth $(S - K) + K = S$ if S is greater than K, or worth K if S is less than or equal to K.

So at option expiration, the values of both portfolios are equal for any stock price. That is, the portfolio values equal either S, if S is greater than K, or K if S is less than or equal to K. Therefore, the values of the portfolios must be equal at all other times. Otherwise, riskless arbitrage is possible by purchasing the lower priced portfolio, selling the higher priced portfolio, and reversing the position when the options expire and the two portfolios are equal in value. So equating the values of the two portfolios we get:

$$Value\ of\ Portfolio\ A = Value\ of\ Portfolio\ B$$

$$S + P = C + PV(K)$$

where: P = the put price, and

C = the call price

The equation above is the put-call parity relationship between the price of a European call option and the price of an identical European put on a non-dividend paying stock. The equation is important because once the price of either option is determined, the price of the other is easily derived from the relationship.

The put-call parity relationship above is easily modified for dividend paying stocks as long as the present value of the dividends paid during the life of the options is known. Denoting this latter quantity by D, the relationship for European options on a stock that pays dividends is:

$$S - D + P = C + PV(K)$$

A similar parity relationship between the prices of American calls and puts doe not exist. As we discussed in the previous section, an American call on a non-dividend paying stock is equivalent to an identical European call because the early exercise feature has no value. However, an American put is worth more than its European equivalent because the right to exercise the option early is positively priced. Therefore, the prices of an American call and put cannot be equated with the price of the underlying stock and a bond because this price difference is not taken into account. This is also the case for American options on dividend paying stocks because the value of the early exercise feature is not the same for calls and puts.

Chapter Four

The Sensitivity Of Option Prices To The Determinants Of Option Value: The Greeks

In the previous chapter, we saw that the price of an option on a nondividend paying stock depends upon five variables:

- the price of the underlying stock, S
- the strike price of the option, K
- the volatility of the underlying stock, σ
- the riskless interest rate, r
- the time remaining to option expiration, t

In this chapter, we examine the sensitivity of option prices to these underlying pricing variables. We do so by defining and discussing parameters that measure just how much the option price changes for a given change in the value of each variable. Historically these sensitivities have been denoted by Greek letters, and so they are often referred to as "The Greeks."

A. Sensitivity to Stock Price: Delta

The most important variable that affects the price of an option is the price of the underlying stock. The parameter that measures the sensitivity of the option price to the stock price is **delta** (Δ). We define delta as the change in the price of an option for a one dollar change in the price of the underlying stock. For example, if the delta of an option is 0.5, then the option price *increases* or *decreases* by approximately \$0.50 when the stock price *increases* or *decreases* by \$1.00. If the delta is -0.50 then the option price *decreases* or *increases* by approximately \$0.50 when the stock price *increases* or *decreases* by \$1.00.

Delta can then be expressed as

$$\Delta = \frac{(C_2 - C_1)}{(S_2 - S_1)} = \frac{\Delta C}{\Delta S}$$

where ΔC is the change in the option price, and ΔS is the change in the stock price.

Strictly speaking, delta is the change in the option price for an infinitesimally small change in the stock price, that is, delta is the *first partial derivative* of the option price with respect to the stock price. However, we will use the definition above in order to simplify the discussion.

The delta of a call option is *always positive* because a call becomes less OTM or more ITM and more valuable as the stock price increases. Conversely, the delta of a put option is *always negative* because a put becomes less ITM or more OTM and less valuable as the stock price increases.

Consider a call option with only a few days remaining to expiration that has a strike price of $100 and whose underlying stock price is currently $50. The call is virtually worthless because the stock price has to more than double in just a few days for the call to expire ITM. If the stock price increases $1 to $51, the option remains almost worthless because the stock price still has to almost double for the call to expire with any intrinsic value. Thus, the delta of a far OTM call option must be very close to zero since the call price does not change with a $1 increase in the stock price.

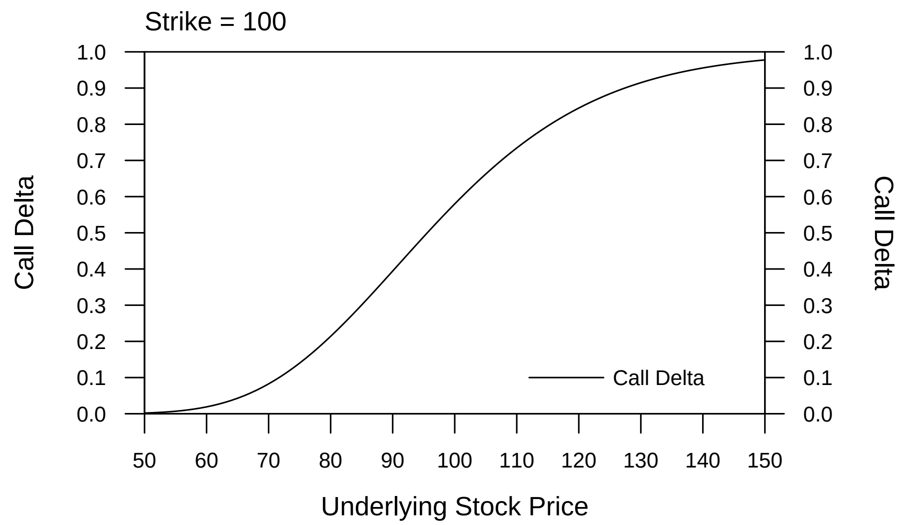
Now consider the same call option when the underlying stock price is $150. The call is now deep ITM and has $50 of intrinsic value and a few cents of time value. If the stock price increases $1 to $151, the call must appreciate by close to $1 because if exercised, the stock purchased for $100 can be sold for an additional $1 of profit. So the delta of a deep ITM call option must be very close to one since the call price increases by almost $1 for a $1 increase in the stock price. Therefore, the delta of a call option ranges from 0 to +1.

The same reasoning can be applied to an OTM and an ITM put option to establish that the delta of a put ranges from 0 to -1. The relationship between delta and the underlying stock price for a European style call and put is shown graphically in Figures 14 and 15. These graphs were generated using the Black-Scholes option pricing formula with the following option parameters:

- Strike Price = 100
- Volatility = 35% per year
- Time Remaining to Expiration = 150 days
- Interest Rate = 5% per year
- Dividends = 0

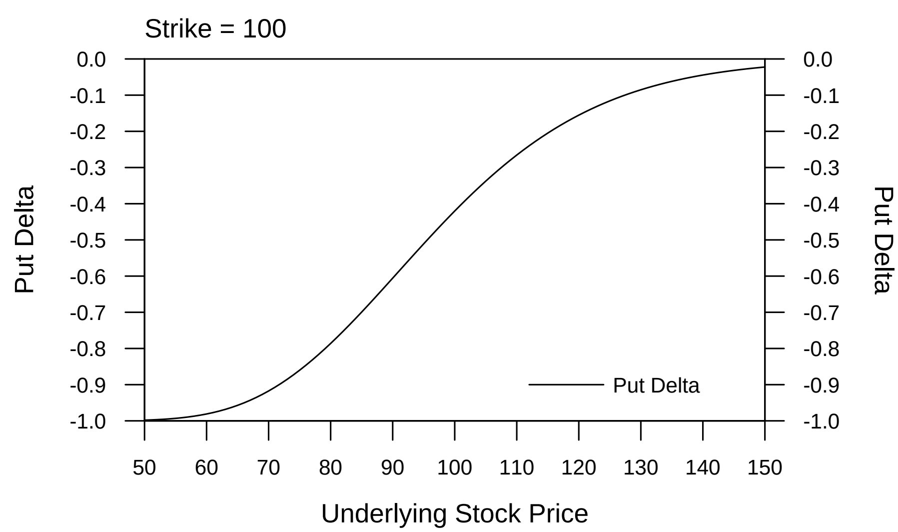
The same parameters are used for all subsequent graphs unless noted otherwise.

Figure 14. Call Delta versus Underlying Stock Price



Source: Smith Barney Inc./Salomon Brothers Inc.

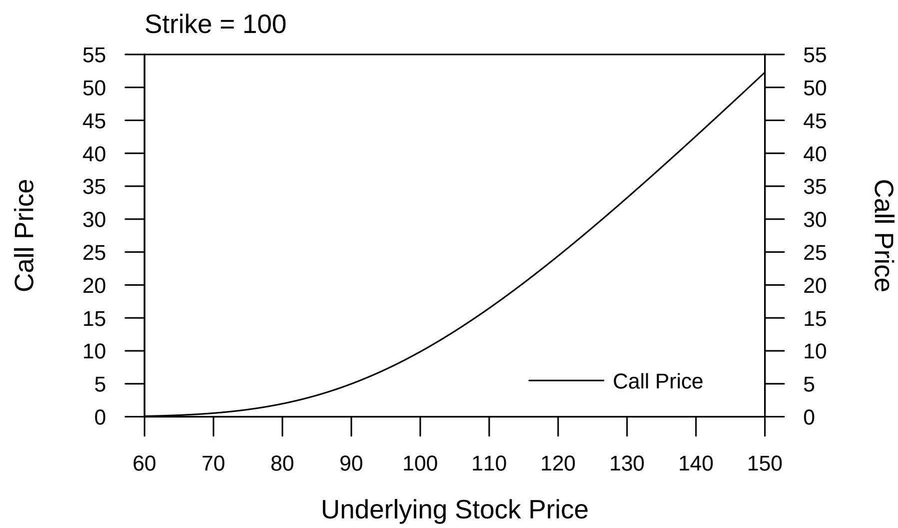
Figure 15. Put Delta versus Underlying Stock Price



Source: Smith Barney Inc./Salomon Brothers Inc.

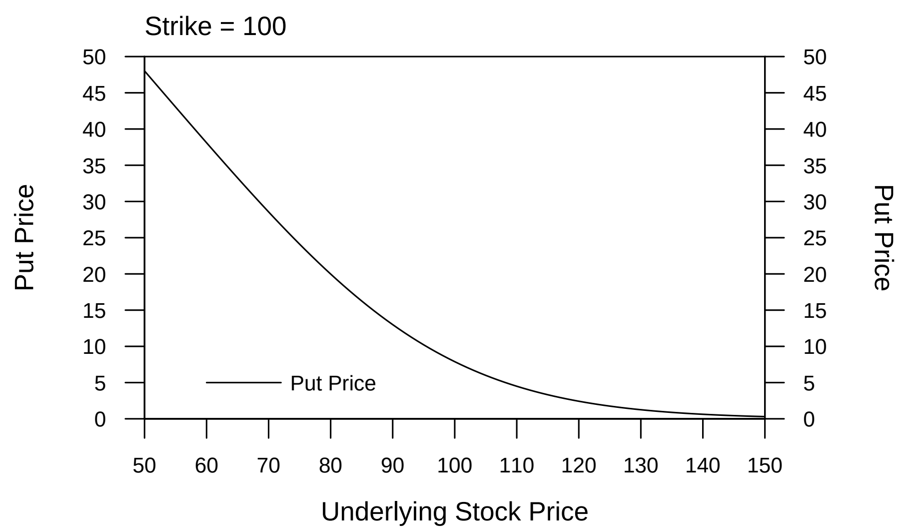
Figures 16 and 17 are the same as Figures 3 and 4 from the previous chapter and again show how the prices of a call and a put vary with the underlying stock price.

Figure 16. Call Price versus Underlying Stock Price



Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 17. Put Price versus Underlying Stock Price



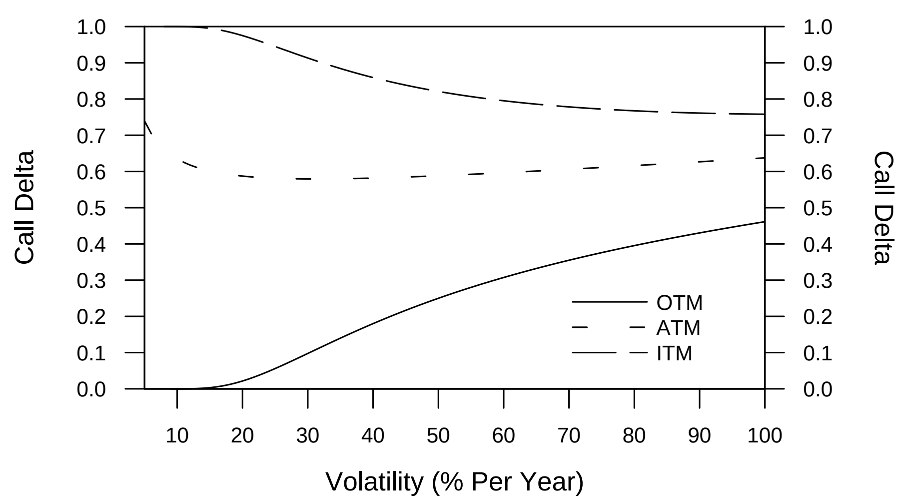
Source: Smith Barney Inc./Salomon Brothers Inc.

Notice from Figures 16 and 17 that as the options become more ITM and the curves become steeper, the option prices undergo a larger change for a given change in stock price, i.e., delta increases. When the options are OTM and the price curves are nearly flat, the option prices change very little for a given change in stock price, and delta is close to zero. When the options are deep ITM, the curves are steepest. Here the option prices change almost one for one with the stock price, and delta is nearly one. These observations can be seen directly in Figures 14 and 15.

Delta can also be loosely interpreted as an approximate measure of the probability that an option will expire ITM. Hence, a far OTM call for which the underlying stock price has little chance of rising above the strike price has zero delta. A deep ITM call which is almost certain to expire ITM has a delta of one. ATM calls have deltas close to 0.5 which is consistent with this interpretation. If stock price moves are random, then the price has roughly a 50-50 chance of increasing and being above the strike price at expiration.

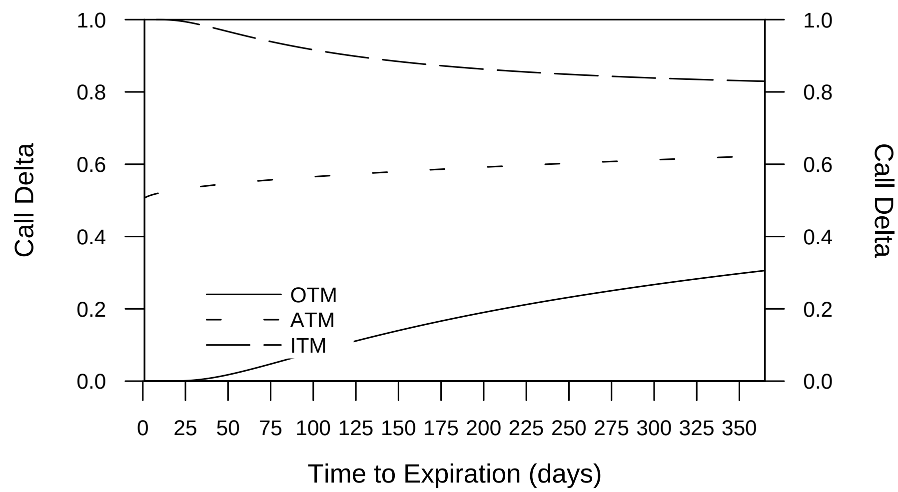
This interpretation of delta also provides insight into its relationships with some of the other determinants of option value. For example, if a call option is OTM, the probability of it expiring ITM increases as both the volatility and the time remaining to expiration increase. Higher volatility gives the stock price a greater likelihood of undergoing a larger increase, and longer time to expiration gives the stock a greater time interval in which to do so. Therefore, the delta of an OTM call should *increase* as both the volatility and the time remaining to expiration *increase*. For similar reasons, the delta of an ITM call should *decrease* as the volatility and the time remaining to expiration *increase*. These relationships between delta and both the volatility and the time to expiration are shown for calls in Figures 18 and 19 and for puts in Figures 20 and 21.

Figure 18. Call Delta versus Volatility for Different Stock Prices



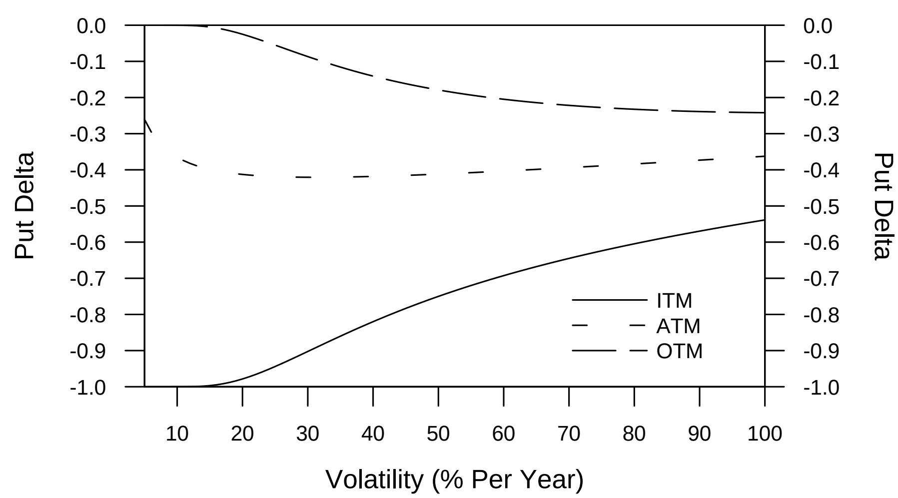
Source: Smith Barney Inc./Salomon Brothers, Inc.

Figure 19. Call Delta versus Time to Expiration for Different Stock Prices



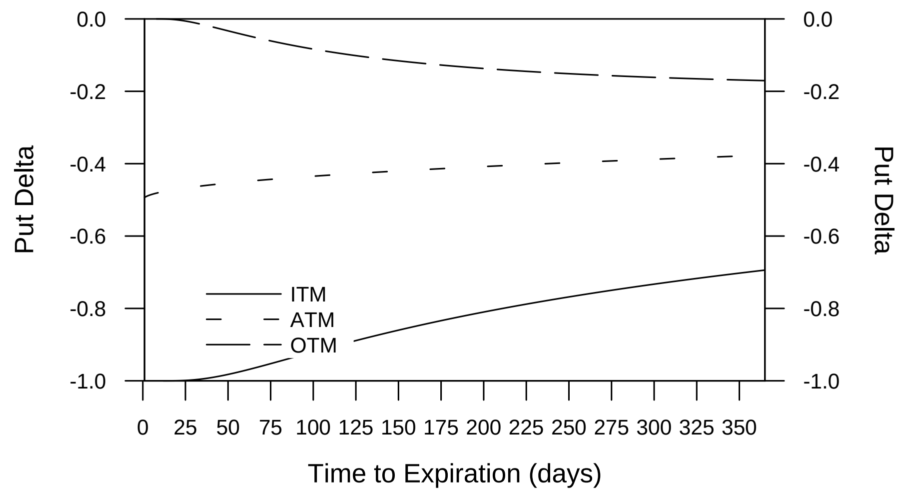
Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 20. Put Delta versus Volatility for Different Stock Prices



Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 21. Put Delta versus Time to Expiration for Different Stock Prices



Source: Smith Barney Inc./Salomon Brothers Inc.

We now present some simple examples of how delta is used by option buyers and sellers in some common investment and trading situations.

Estimating Short Term Profit Potential

In the next chapter, we discuss many options strategies and depict their profit and loss characteristics with graphs known as **payoff diagrams**. A standard payoff diagram shows the profit and loss of an option as a function of the underlying stock price *when the option expires*. However, it is equally important to know the profit and loss of an option as a function of the *current stock price*. This is precisely the information provided by delta, and it helps investors to estimate the gain or loss from closing out an option position at any time during the option's life.

For example, assume that an investor expects the price of a stock to decline over the next few days because he or she feels that the current high price of $100 is a result of unfounded takeover rumors. Instead of shorting the stock, the investor buys an ATM put option with 50 days remaining to expiration for $5. Shorting the stock would result in a large loss if the stock price actually increases significantly, but buying the put option limits any such loss to the $5 premium, plus commissions.

The delta of the put option described above is about -0.45. Therefore, the put price will increase by approximately $0.45 for every $1 decrease in the stock price. So if the stock price decreases $1 over the next few days, then the investor will earn approximately $0.45 by selling the put immediately after the price decline. In contrast, if the stock price decreases by $1 at expiration, then the put expires $1 ITM, but the investor loses the $5 premium for a net loss of $4.

Hedging Stock Price Risk: Delta Neutral Strategies

In the next chapter, we discuss three factors that influence the choice of an appropriate options strategy:

- The outlook for the price of a stock or for the level of the overall stock market,
- The outlook for the volatility of a stock or of the overall market, and
- The investor's preference for risk and return.

Delta is used to hedge the price risk of the underlying stock when the second factor above, the outlook for the stock volatility, motivates the choice of an options strategy.

Option mispricing can arise from short-term order imbalances that temporarily perturb the supply and demand equilibrium, or from pricing options with incorrect values of the underlying variables. Since the only option pricing variable that is not known with certainty is the volatility of the underlying stock, then the volatility is the only variable that can lead to mispricing. So if the price of an option in the marketplace is greater than the fair or theoretical price calculated from an option pricing equation, then the consensus estimate of the stock volatility between now and expiration must be higher than the volatility used to calculate the fair value. If the consensus or implied volatility decreases in the future before the option expires, then the option price will also decrease assuming that all of the other pricing variables remain constant. Selling the option now and buying it back when the implied volatility and the price decrease will be profitable. So trading mispriced options is thus motivated by one's outlook on the stock volatility rather than the stock price.

For example, assume that the ZYX Jun 100 call with 150 days remaining to expiration is currently five points OTM and is priced at $9.60 with an implied volatility of 45%. A trader believes that the true volatility is closer to 35% and the fair value is closer to $7.20, so he or she writes the call. Fifty days from now, the underlying stock price is still $95, the implied volatility decreases to 35%, and the option price decreases to $5.40. The trader then buys back the call and realizes a profit of ($9.60 - $5.40) = $4.20. If the initial margin requirement is 20% of the underlying stock price or $19, then the return on the transaction is 22%. The trader thus profits from both an accurate forecast of the stock volatility and from the time decay of the option premium.

The profitable outcome of this example also depends upon the unlikely event of the stock price being the same when the call is repurchased as when it is initially written. If, in addition to the volatility, the stock price also decreases, then the trader's profits are even greater because the decrease in the call price is even greater. However, if the stock price increases, then the call price also increases, profits decrease, and they become zero if the stock price increases by only \$8 or 8.5%. Thus, potential profits from volatility trades can easily be erased by underlying stock price moves. Therefore, profitable volatility trading requires hedging the stock price risk.

The delta of the ZYX call described above is approximately 0.5. So a \$1 increase in the price of the underlying results in a \$0.50 increase in the call price and a concurrent \$0.50 decrease in the trader's profits. If, however, the trader also happens to own the equivalent of 1/2 share of the underlying stock, then the \$0.50 loss from the written call due to the \$1 stock price increase is offset by a \$0.50 increase in the stock position, and the desired hedge is achieved.

Consider now the delta of this hedged position. The delta of any position consisting of stock and options on the same stock is simply the sum of the total stock delta and the total options delta. The total stock delta is the number of stock shares times the stock delta, and the total options delta is the number of options times the option delta. The position delta can then be written as

$$\Delta_{POS} = (N_C \times \Delta_C) + (N_S \times \Delta_S)$$

where

$\Delta_{POS} =$ the position delta,

$N_C =$ the number of call options,

$\Delta_C =$ the call delta,

$N_S =$ the number of stock shares, and

$\Delta_S =$ the stock delta.

The quantities N_C and N_S are negative if the calls are written and the stock is sold short.

Noting that the stock delta must always be +1, the equation above reduces to:

$$\Delta_{POS} = (N_C \times \Delta_C) + N_S$$

For the example above we then have:

$$\Delta_{POS} = (-1 \times 0.5) + 0.5 = 0$$

Therefore, the desired hedge is achieved when the position delta is zero. Then the position value remains unchanged for any small change in the stock price, and the position is said to be **delta hedged** or **delta neutral**.

The second equation above can also be used to compute the number of stock shares required to achieve a delta neutral position by letting Δ_{POS} equal 0 and solving for N_S:

$$N_S = -N_C\Delta_C = (-1 \times 0.5) = -0.5$$

The third equation above can also be used to compute the option delta required for a delta neutral position by letting Δ_{POS} equal 0 and solving for Δ_C:

$$\Delta_C = -\left(\frac{N_S}{N_C}\right)$$

Therefore, the option delta can also be interpreted as the ratio of the number of shares of stock to the number of options in a delta neutral position. Note that the minus sign indicates that the stock and options positions are on opposite sides of the market. For this reason the option delta is often referred to as the **hedge ratio**. So if a call delta is 0.75, then 75 shares of long stock per written call contract are required for delta neutrality.

Note that delta neutrality can also be achieved by buying or selling other options on the same stock. In the example above, the delta of the written call is -0.5. This position can also be delta hedged by buying a different ZYX call with a delta of 0.5, by writing a ZYX put with a delta of -0.5, or by using a combination of long ZYX stock, written ZYX puts, and other long ZYX calls that has a net delta of +0.5. However, when other options are used to delta hedge, the position delta becomes more sensitive to market conditions and must be monitored closely to insure that it remains zero. For example, Figures 14, 15, and 18 through 21 show how option deltas vary with stock price, volatility, and time to expiration. As these parameters change in the marketplace, so will the position delta.

Risk Management

The position delta is also used to measure and manage the risk of portfolios that contain both stock and options. For example, one of the option strategies that we discuss in the next chapter is known as a long collar and is implemented with a portfolio consisting of long stock, a written OTM call, and a long OTM put. Consider the long collar whose payoff diagram is shown in Figure 41. The position consists of the following securities:

Security	Number of Shares or Options	Total Delta
ZYX Stock	100	100
ZYX Jun 110 Call	-100	-41
ZYX Jun 90 Put	100	-25

Summing the total deltas gives a position delta of +34. Thus, a \$1 increase or decrease in the price of the underlying ZYX stock results in a \$34 increase or decrease in the value of the overall long collar position.

One of the goals of risk management is to estimate the amount that individual and aggregate security positions can lose over a specified period of time. The most common tool for making such estimates is a **value at risk** (**VAR**) model. We illustrate the use of a simple version of this model in the following example.

Assume that the current price of ZYX stock is \$100 and the volatility of ZYX is 35% per year which corresponds to 2.2% per day. If the daily returns of ZYX are normally distributed, then the probability is roughly 68% that the price of ZYX tomorrow will be within one daily standard deviation or one volatility unit of today's price, i.e., between \$97.80 and \$102.20. We define the overnight value at risk of ZYX as the one-day decrease in price for which a larger decrease is only 5% probable. That is, the probability is 5% that the stock price will decline by one VAR *or more* in a single day. As defined, the VAR corresponds to a price decline of 1.65 volatility units. So the VAR per share of stock is given by

$$VAR = (1.65)(\sigma)(S) = 3.63$$

where

σ = the overnight or one day volatility, and

S = the stock price.

Thus, the probability is 5% that the price of ZYX will fall by \$3.63 *or more* in a single day.

The position VAR is then the stock VAR times the position delta, or (34)(3.63) = \$123. So the probability is 5% that the value of the long collar described above will decrease by \$123 or more in a single day. The VAR can be reduced by decreasing the position delta using the previously described delta hedging techniques. For example, the position can be made delta neutral with a zero VAR by selling 34 shares of ZYX and thereby reducing delta by the necessary 34 points.

B. Sensitivity to Stock Returns: Omega

A parameter that is closely related to delta is **omega** (Ω), which is also known as the **option elasticity**. We define omega as the percent change in the price of an option when the underlying stock price changes by one percent. For example, if the omega of an option is +5, then the option price *increases* or *decreases* by approximately 5% when the stock price *increases* or *decreases* by 1%. If omega is -5, then the option price *decreases* or *increases* by approximately 5% when the stock price *increases* or *decreases* by 1%. So omega is a measure of the option return per unit of stock return.

If ΔC and ΔS are incremental changes in the prices of a call option and its underlying stock, then omega is given by:

$$\Omega = \left(\frac{\Delta C}{C} \bigg/ \frac{\Delta S}{S} \right) = \left(\frac{\Delta C}{\Delta S} \bigg/ \frac{S}{C} \right) = \frac{S}{C} \Delta_C$$

where Δ_C is the delta of the call. The omega of a put is defined similarly.

Omega thus equals the ratio of the stock price to the option price, times the option delta.

Consider a call option with an omega of +5. If the stock price increases by 1%, then the call price increases by 5%. This same return can be realized by buying one share of stock and borrowing sufficient funds to purchase another $(\Omega - 1) = 4$ shares. So omega is also a measure of the *leverage value* of an option.

A pure speculator who seeks to maximize profits by buying calls with all available funds when he or she expects the price of a stock to rise uses omega to select the best call. Assume that the speculator has a total amount of V to invest. Then the profit from a long position in calls is given by:

$$\text{Profit} = \frac{V}{C} \Delta C$$

where (V/C) is the number of calls and ΔC is the change in the call price. We also assume that any change in the call price is due only to a change in the underlying stock price, that is, the holding period is short so that time decay is negligible, and the implied volatility is constant.

From the definition of omega, we have that

$$\frac{\Delta C}{C} = \Omega \frac{\Delta S}{S}$$

Substituting the first equation above into the second equation above we get:

$$\Pr ofit = V\Omega \frac{\Delta S}{S}$$

Therefore, the call with the largest omega maximizes profits for a given percent increase in the price of the underlying, $(\Delta S/S)$.

A final application of omega is relating the total risk and the market risk of an option to that of its underlying stock. The appropriate relationships are

$$\sigma_{option} = \Omega\sigma_{stock}$$

$$\beta_{option} = \Omega\beta_{stock}$$

where σ is the total risk or volatility, and β is the usual measure of market risk.

C. Sensitivity of Delta to Stock Price: Gamma

Figures 14 and 15 show that the delta of a call and a put vary from 0 to 1 and from 0 to -1, respectively, as the underlying stock price varies. Therefore, delta, like the option price itself, is sensitive to the stock price. The parameter that measures this sensitivity is **gamma** (Γ). We define gamma as the change in the delta of an option per $1 change in the price of the underlying stock. For example, if the gamma of an option is 0.10, then the option delta *increases* or *decreases* by approximately 0.10 delta unit when the stock price *increases* or *decreases* by $1. Note that the option gamma is *always positive* and is the same for a call and a put with the same strike price and time to expiration.

So gamma can be expressed as

$$\Gamma = \frac{(\Delta_2 - \Delta_1)}{(S_2 - S_1)}$$

Gamma measures the effect that a stock price change has on a subsequent stock price change. For example, consider a call option with a delta of 0.50 and a gamma of 0.10. If the stock price increases by $1, then the call price increases by $0.50 because of delta, and delta increases by 0.10 from 0.50 to 0.60 because of gamma. If the stock price increases again by $1, then the call price increases by $0.60 because delta is now 0.60, and delta increases by another 0.10 to 0.70.

If the stock price increases by $2 in a single move, then the call price increases by $1.10. However, the original delta of 0.50 predicted an increase of only $1.00. So as gamma increases, the option price increase predicted by delta becomes valid only for smaller stock price increases. That is, gamma causes the actual increase in the option price per $1 increase in the stock price to be larger than the increase predicted by delta.

Now consider the example above when the stock price *decreases*. If the stock price decreases by $1, then the call price decreases by $0.50 because of delta, and delta decreases by 0.10 from 0.50 to 0.40 because of gamma. If the stock price decreases again by $1, then the call price decreases by only $0.40 because delta is now 0.40, and delta decreases by another 0.10 to 0.30.

If the stock price decreases by \$2 in a single move, then the call price decreases by \$0.90. However, the original delta of 0.50 predicted a decrease of \$1.00. So as gamma increases, the option price decrease predicted by delta becomes valid only for smaller stock price decreases. That is, gamma causes the actual decrease in the option price per \$1 decrease in the stock price to be smaller than the decrease predicted by delta.

The significance of the above is as follows. An investor who believes that the price of a stock is about to rise can profit by constructing a stock and option portfolio with a positive delta. If the portfolio also has a positive gamma, then the increase in the value of the portfolio for a given increase in the price of the underlying stock will be *greater than* that predicted by the static delta. It is equally significant that if the investor's outlook is incorrect and the stock price actually decreases, then the decrease in the value of the portfolio will be *less than* that predicted by the static delta. So positive gamma enhances the profits and dampens the losses of a positive delta strategy.

A similar argument shows that positive gamma has the same effect on a negative delta strategy. That is, if gamma is positive, then the increase in the value of a negative delta position for a given decrease in the price of the underlying stock is greater than that predicted by the static delta. Likewise, the decrease in the position value for a given increase in the underlying price is less than that predicted by the static delta.

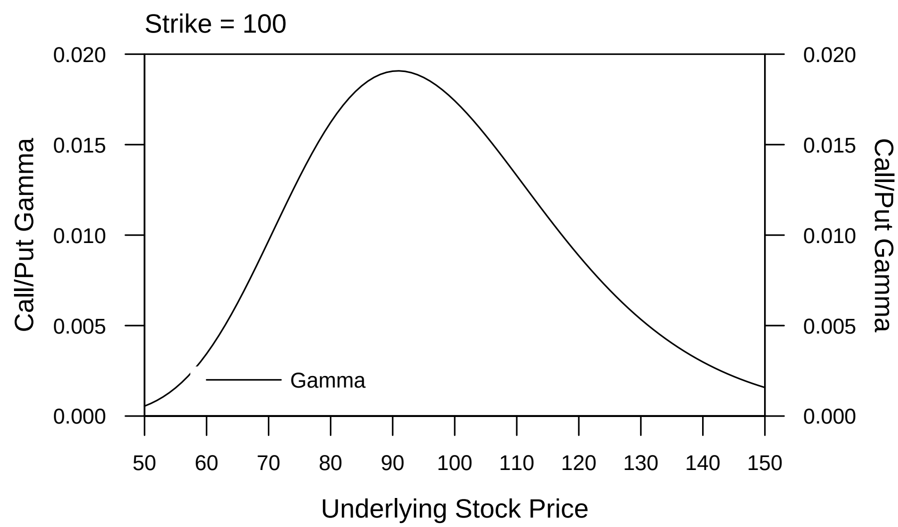
We can also show that negative gamma has the opposite effect. Negative gamma dampens the profits and enhances the losses of both positive and negative delta positions. Therefore, whenever possible, both positive delta and negative delta strategies should also have positive gamma.

Now consider the effect of gamma on a delta neutral position. If the position gamma is positive and the stock price increases, then the position value does not change because delta is zero, but delta increases from zero to a positive number. A second stock price increase then increases the position value because delta is now positive. If the position gamma is positive but the stock price decreases, then the position value again does not change because delta is zero, but now delta decreases from zero to a negative number. However, a second stock price decrease still increases the position value because delta is now negative. Therefore, a large change in the price of the underlying in either direction increases the value of a delta neutral position if gamma is positive. Conversely, if the position gamma is negative, a large stock price change in either direction decreases the value of a delta neutral position.

The only way to ensure that the value of a delta neutral position does not change when the underlying stock undergoes a large price move is to make the position **gamma neutral** by **gamma hedging** and setting the position gamma equal to zero. If gamma is zero, then any stock price move does not affect delta and it remains zero. If delta remains zero, then any stock price move does not affect the position value. However, since the delta of the underlying stock is always constant and equal to 1, then the stock gamma is always zero. Therefore, gamma hedging can only be accomplished with other options. Furthermore, since the gamma of long calls and puts is always positive, then long options can only be gamma hedged with written options.

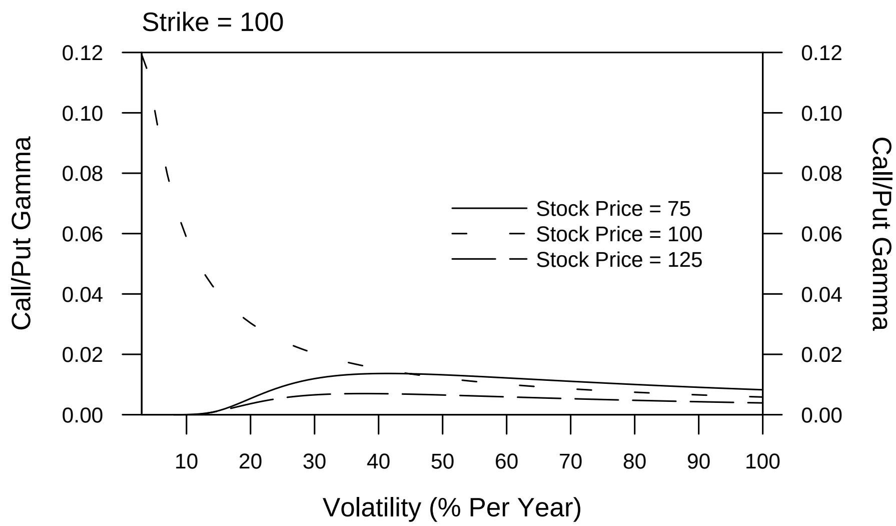
Gamma is inversely proportional to the stock price and varies from about 0.02 to about 0.10 for ATM options. Gamma *increases* as both the time to expiration and the stock volatility *decrease* and as the option gets near-the-money. The sensitivity of gamma to these parameters is shown in Figures 22 through 24. Note that the two latter figures actually depict call gammas versus the pricing variables. However the gamma of an ATM call is the same as the gamma of an ATM put, and the graph for the ITM (OTM) put is the same as the graph for the OTM (ITM) call.

Figure 22. Call or Put Gamma versus Underlying Stock Price



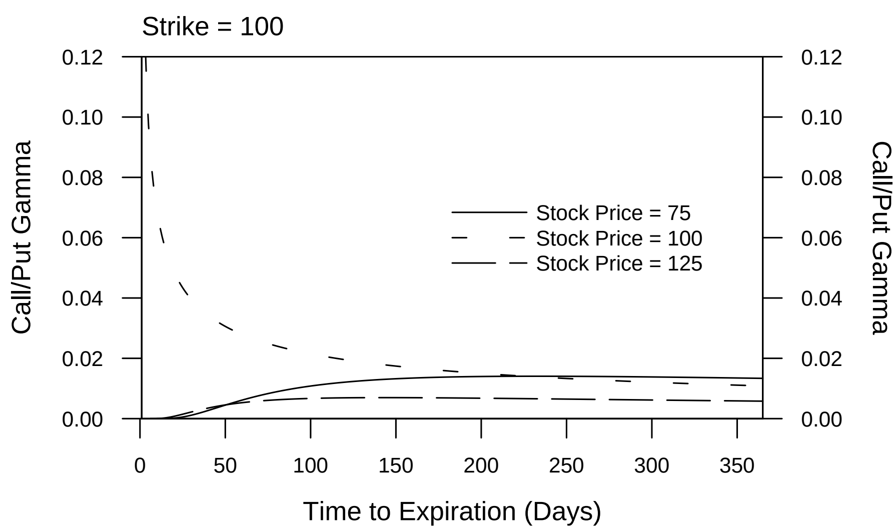
Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 23. Call or Put Gamma versus Volatility for Different Stock Prices



Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 24. Call or Put Gamma versus Time to Expiration for Different Stock Prices



Source: Smith Barney Inc./Salomon Brothers Inc.

D. Sensitivity to Stock Price Volatility: Vega

The parameter that measures the sensitivity of the option price to the volatility of the underlying stock is **vega**. Since vega is not a Greek letter, the parameter is sometimes referred to as **kappa** (K), which is. We define vega or kappa as the change in the price of an option for a 1% change in the annual volatility of the underlying. For example, if the vega of an option is 0.25, then the option price *increases* or *decreases* by approximately $0.25 when the annual volatility of the underlying stock *increases* or *decreases* by 1%. Note that by a change in the annual volatility we mean an absolute change, e.g., an increase from 35% a year to 36% a year. Vega is always positive because every option increases in value as the volatility increases, and vega is the same for a call and a put with the same strike price and time to expiration.

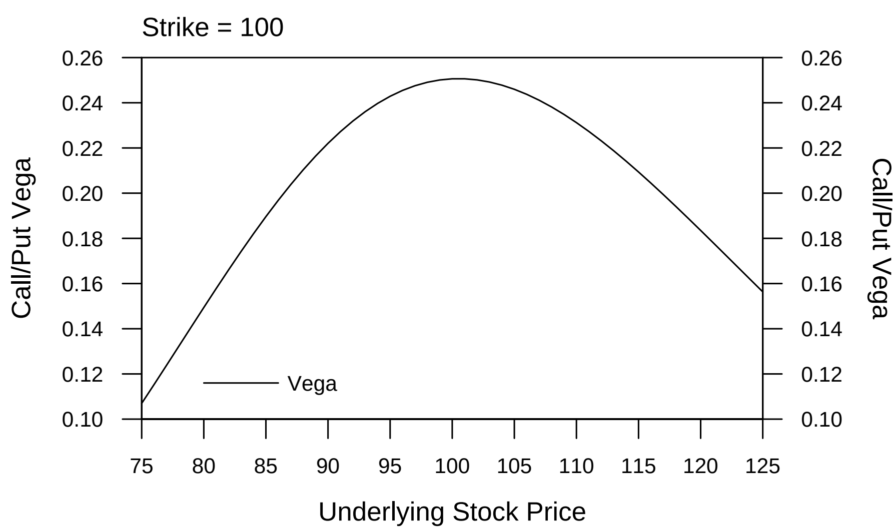
So vega or kappa can be expressed as:

$$K = \frac{(C_2 - C_1)}{(\sigma_2 - \sigma_1)}$$

The underlying stock volatility is not known with certainty and can change significantly during the lifetime of an option. Therefore, option price changes due to volatility changes can be large and frequent if vega is large. So if traders are long options and expect volatility to increase or decrease, then they should accordingly increase or decrease their position vega. Traders who are uncertain about the magnitude of future volatility should accordingly vega neutralize their position. Also, vega, like gamma, can measure the sensitivity of the option price to a large move in the underlying price if the latter increases the volatility.

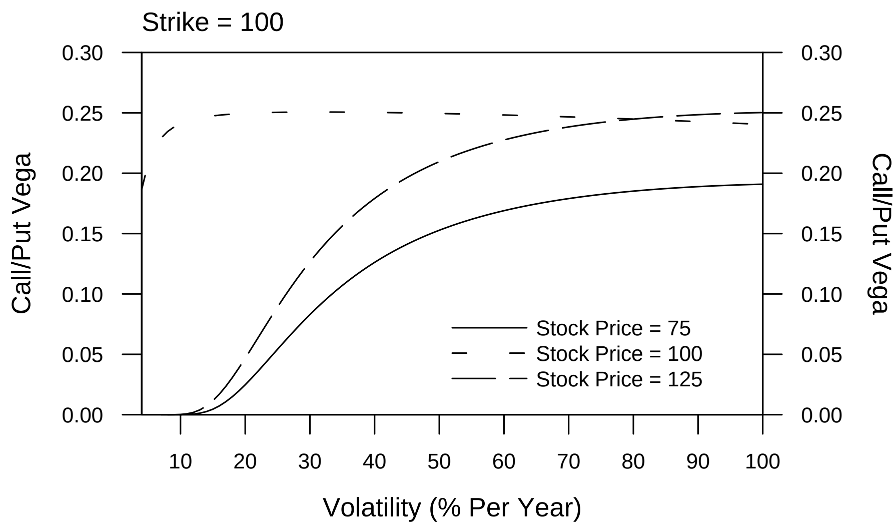
The sensitivities of vega to the underlying stock price, volatility, and time to expiration are shown in Figures 25 through 27. Note from these figures that ATM options have the largest vega, and so their prices are most sensitive to changes in volatility. Note also that vega generally increases as both the volatility and the time to expiration increase.

Figure 25. Call or Put Vega versus Underlying Stock Price



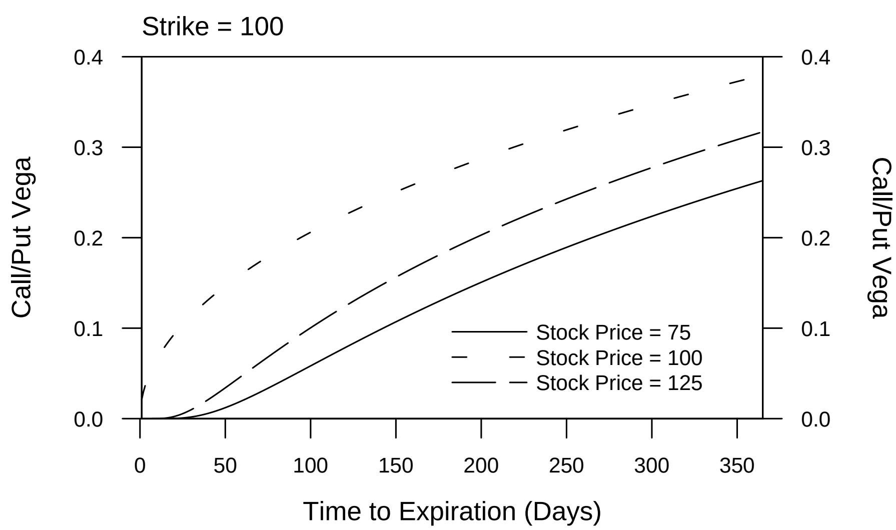
Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 26. Call or Put Vega versus Volatility for Different Stock Prices



Source: Smith Barney Inc./ Salomon Brothers Inc.

Figure 27. Call or Put Vega versus Time to Expiration for Different Stock Prices



Source: Smith Barney Inc./Salomon Brothers Inc.

Note again that Figures 26 and 27 actually depict call vegas versus the pricing variables. However, the vega of an ATM call is the same as the vega of an ATM put, and the graph for the ITM (OTM) put is the same as the graph for the OTM (ITM) call.

E. Sensitivity to Time to Expiration: Theta

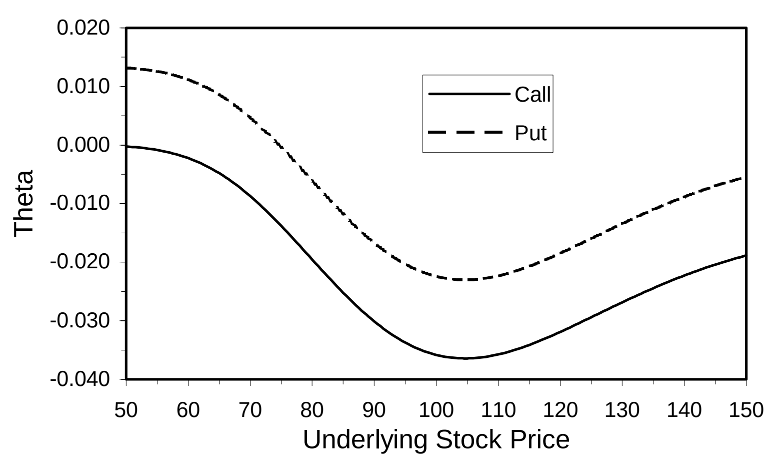
The parameter that measures the sensitivity of the option price to the time remaining to expiration of the option is **theta** (Θ). We define theta as the change in the price of an option for a one day passage of time. We saw in the previous chapter that all options lose value as time moves forward and the number of days to expiration decreases. Therefore, the theta of a long option is always negative as defined above because a negative change or decrease in the option price always occurs for a positive change in time. For example, if the theta of an option is -0.10, then the option price increases or decreases by approximately \$0.10 when the number of days to expiration increases or decreases by one.

So theta can be expressed as:

$$\Theta = \frac{(C_2 - C_1)}{(t_2 - t_1)}$$

The variation of theta with the underlying stock price is shown in Figure 28 for both a call and a put. Theta is a maximum or most negative when both options are almost ATM and becomes less negative as the stock price increases or decreases. Note also that the theta of a put can be *positive* when the put is deep ITM. To understand why this is the case, recall that time affects both the volatility value and the leverage value of an option. As time passes, the volatility has less time to vary the stock price, and the option has less time to expire ITM. This effect contributes a negative component to theta. However, for a put option, as time passes, the leverage value increases because the owner forfeits less interest by postponing receipt of the strike price. This effect contributes a positive component to theta. When the put is deep ITM, the volatility value is very small and insensitive to changes in time, so the positive leverage component of theta dominates. Theta thus becomes more positive as the put goes deeper ITM and as the time to expiration and the interest rate increase.

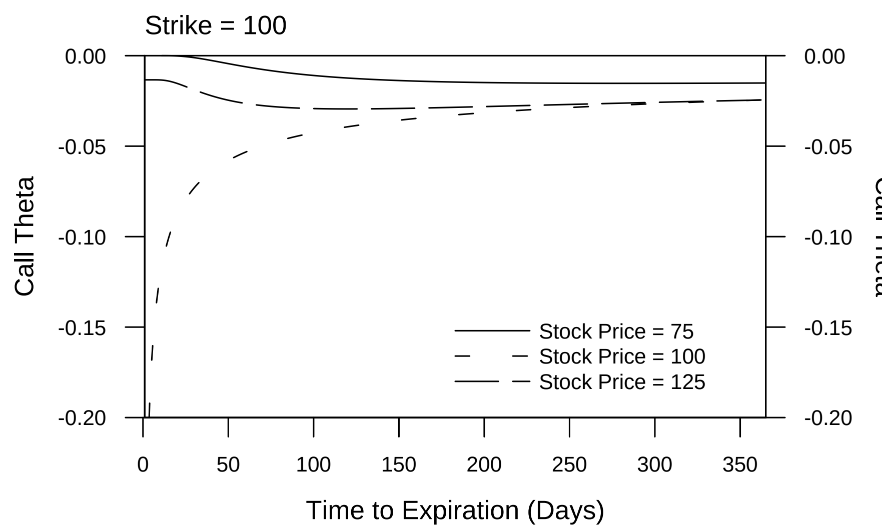
Figure 28. Call and Put Theta versus Underlying Stock Price



Source: Smith Barney Inc./Salomon Brothers Inc.

The variation of theta with the time to expiration is shown in Figure 29 for a call option. Note that the theta of ITM and OTM options varies very little with time until the options are close to expiration. Then theta slowly goes to zero. The theta of an ATM option increases (becomes more negative) slowly as time passes and then increases very rapidly near expiration.

Figure 29. Call Theta versus Time to Expiration for Different Stock Prices



Source: Smith Barney Inc./Salomon Brothers Inc.

A general relationship exists among the gamma, vega, and theta of any portfolio of options. Gamma and vega usually have the same sign which is usually opposite to the sign of theta. Therefore, positive gamma-positive vega-negative theta positions that increase in value from a large price move in the underlying stock or from an increase in volatility always lose value from time decay. Conversely, negative gamma-negative vega-positive theta positions that decrease in value from a large price move in the underlying stock or from an increase in volatility always increase in value over time. One exception to this rule is the deep ITM put option that we just discussed. The signs of gamma, vega, and theta are the same for a deep ITM put.

F. Sensitivity to the Interest Rate: Rho

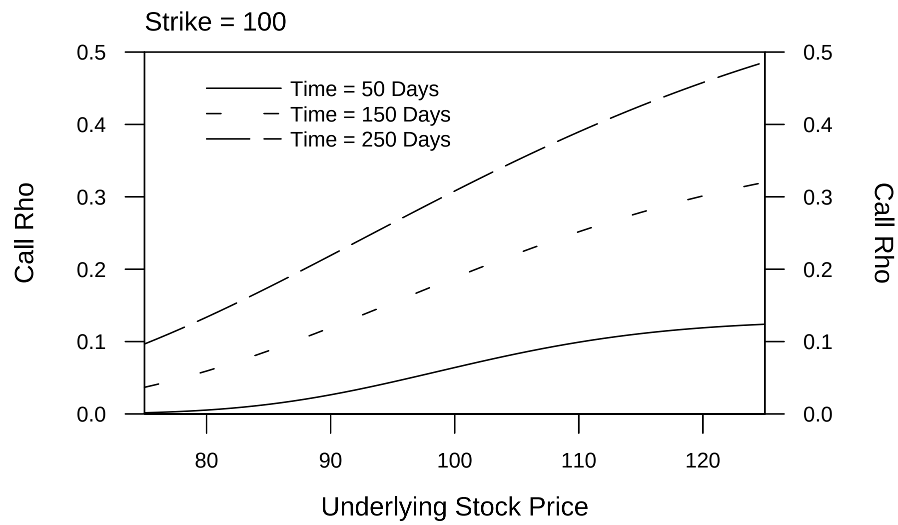
The parameter that measures the sensitivity of the option price to the interest rate is **rho** (P). We define rho as the change in the price of an option for a 1% change in the annual rate of interest. For example, if the rho of an option is 0.25, then the option price *increases* or *decreases* by approximately $0.25 when the annual interest rate *increases* or *decreases* by 1%. If rho is -0.25, then the option price *decreases* or *increases* by approximately $0.25 when the annual interest rate *increases* or *decreases* by 1%. Note that by a change in the annual interest rate we mean an absolute change, e.g., an increase from 5% per year to 6% per year.

So rho can be expressed as:

$$\mathrm{P} = \frac{(C_2 - C_1)}{(r_2 - r_1)}$$

The rho of a call option is always positive, and the rho of a put option is always negative because call prices always increase with increasing rates and put prices always decrease with increasing rates. Figure 30 shows the variation of the rho of a call option with the underlying stock price for three different times to expiration. The corresponding behavior of the rho of a put option with the underlying stock price is very similar except that rho is negative.

Figure 30. Call Rho versus Underlying Stock Price for Different Times to Expiration



Source: Smith Barney Inc./Salomon Brothers Inc.

G. Summary

The signs of the sensitivities of option prices to the determinants of option value are summarized in the following table.

Asset	Delta	Omega	Gamma	Vega	Theta	Rho
Long Stock	+	+				
Short Stock	-	-				
Long Call	+	+	+	+	-	+
Short Call	-	-	-	-	+	-
Long Put	-	-	+	+	-,+	-
Short Put	+	+	-	-	+,-	+

If an option position has a positive or negative sensitivity to one of the option pricing variables, then the position value will increase or decrease as the pricing variable increases. This is summarized in the following table.

Position Sensitivity	Event	Position Value
Positive Delta	Stock Price Increases	Increases
Negative Delta		Decreases
Positive Omega	Stock Price Increases	Increases
Negative Omega		Decreases
Positive Gamma	Stock Price Moves Up or Down	Increases
Negative Gamma		Decreases
Positive Vega	Volatility Increases	Increases
Negative Vega		Decreases
Positive Theta	Time Passes	Increases
Negative Theta		Decreases
Positive Rho	Interest Rate Increases	Increases
Negative Rho		Decreases

Chapter Five

Options Strategies

In this chapter we discuss some of the important equity investment strategies that are implemented with options. Section A introduces some of the basic stock substitution, hedging, and volatility strategies that use one or more options on the same underlying stock, or a combination of the options and the stock. Section B discusses arbitrage strategies used primarily by market makers that involve simultaneously buying a stock and selling its synthetic option equivalent or vice versa. Finally, Section C mentions some of the important applications of stock index options and options on stock index futures.

A. Basic Equity Options Strategies

This first section describes the four categories of basic options strategies that use one or more options on the same underlying stock or a combination of the options and the stock. These categories are commonly known as naked or uncovered positions, hedges, spreads, and combinations. The section is divided into two parts. Part 1 discusses some of the factors and considerations that enter into the strategy selection process, and Part 2 discusses each strategy in detail.

1. Selecting a Strategy

There are three factors that motivate the selection of an appropriate options strategy. These factors are:

- The outlook for the price of a stock or for the level of the general stock market,
- The outlook for the volatility of a stock or for the volatility of the general stock market, and
- The investor's preference for risk and return.

a. The Stock Price or Market Level Outlook

The first factor that motivates the selection of an appropriate options strategy is the investor's outlook for the future performance of the underlying stock or the general stock market. We consider three possible outlooks.

1) Bullish Stock Outlook

An investor with a bullish stock outlook expects the price of a stock to increase. So options strategies that reflect a bullish stock outlook are substitutes for long stock strategies and are designed to produce positive returns when the price of the underlying stock increases. We know from Chapter Four that the positions resulting from the implementation of these strategies should have positive delta. We also know from Chapter Four that the positions should also have positive gamma whenever possible. Positive gamma increases the benefits of a positive delta strategy by increasing profits if the stock price does increase and by reducing losses if the stock price instead decreases.

2) Bearish Stock Outlook

An investor with a bearish stock outlook expects the price of a stock to decrease. So options strategies that reflect a bearish stock outlook are substitutes for short stock strategies and are designed to produce positive returns when the price of the stock decreases. Therefore, the positions resulting from the implementation of these strategies should have negative delta. The positions should also have positive gamma whenever possible. Positive gamma increases the benefits of a negative delta strategy by increasing profits if the stock price does decrease and by reducing losses if the stock price instead increases.

3) Neutral Stock Outlook

Options strategies that reflect a neutral stock outlook are appropriate when the investor has no opinion or is completely uncertain about the future direction of the stock price or the level of the general stock market. In this case the investor has other motives for using options such as hedging price risk or implementing volatility strategies. The objective of these strategies then is to eliminate the risk of a stock price move in either direction by making the resulting positions delta neutral. Positive gamma also increases the benefits of a delta neutral strategy by producing positive returns if the stock price undergoes a large unexpected move in either direction.

b. The Stock or Market Volatility Outlook

Options allow investors to profit not only from correctly forecasting the direction of stock prices, but also from correctly forecasting the direction of stock price volatility. So the second factor that motivates the selection of an appropriate options strategy is the investor's outlook for the future level of the underlying stock volatility. We consider three possible volatility outlooks.

1) Increasing or Long Volatility Outlook

An investor with an increasing or long volatility outlook expects the volatility of the underlying stock to rise. So strategies that reflect an increasing or long volatility outlook are designed to produce profits when the future stock volatility increases. We know from Chapter Four that the positions resulting from the implementation of these strategies should have positive vega. We also know from Chapter Four that positive vega positions usually have positive gamma. So for any delta, a positive vega position will also benefit from a favorable stock price move.

2) Decreasing or Short Volatility Outlook

An investor with a decreasing or short volatility outlook expects the volatility of the underlying stock to decline. So options strategies that reflect a decreasing or short volatility outlook are designed to produce profits when the future stock volatility decreases. Positions resulting from the implementation of short volatility strategies should have negative vega. However, negative vega positions usually have negative gamma. So for any delta, a negative vega position will benefit less from a favorable stock price move and will suffer more from an unfavorable stock price move.

3) Neutral Volatility Outlook

Strategies that reflect a neutral volatility outlook are appropriate when the investor has no opinion or is completely uncertain about the future direction of stock volatility. In this case the investor has other motives for using options such as stock substitution. The objective of these strategies then is to eliminate the risk of either an increase or decrease in volatility by making the resulting positions vega neutral.

As an aside to the discussion of the strategies designed to profit from changes in volatility, recall once again from Chapters Three and Four that the price of an option increases or decreases as the underlying stock volatility increases or decreases, and that the magnitude of the increase or decrease is measured by vega. Recall also that every option price reflects the market's view of what the volatility will be over the remainder of the option's lifetime. This value implicit in or implied by the option price in the marketplace is called the implied volatility. If the market becomes more uncertain about the future prospects of a company, then this additional uncertainty will enter the market's pricing mechanism as a higher implied volatility, and the option's price will increase. So an investor who believes that the consensus estimate of a stock's price uncertainty is about to increase (decrease) should implement a long (short) volatility strategy whose resulting position has large positive (negative) vega.

We also saw in Chapter Four that when the price of the underlying stock in a delta neutral position with positive gamma undergoes a large jump in either direction, the value of the position increases. Such a price jump is often exhibited by the stock of a company that is a candidate for takeover or merger. If the market feels that a takeover is likely, the stock price can rise by tens of percent in a single day. However, if the market expectation of a takeover wanes, the price can fall by almost as much. A large price move in either direction can also occur just after the release of either an eagerly awaited earnings report or an economic statistic to which the stock price is especially sensitive. So an investor who expects the price of a stock to undergo a sudden large jump in either direction should implement a strategy that produces a delta neutral position with high positive gamma.

A price jump like that mentioned above will certainly increase the short term historical or realized volatility, but it may or may not increase the implied volatility and the option price. The market may view the price jump as an isolated event that is not likely to occur again during the option's lifetime. In this case, the consensus estimate of the future price uncertainty of the underlying remains the same as does the implied volatility and the option price. On the other hand, the market may view the price jump as the first of a series of anticipated large price swings or as an indication that the future stock price behavior has become more uncertain. In this case, the implied volatility and the option price will increase.

So there is a subtle difference between the motivation for implementing delta neutral-positive gamma strategies and positive vega strategies. Investors implement the former when they anticipate an imminent large price swing but are unsure of the direction. Investors implement the latter when they anticipate an imminent increase in implied volatility. If a large price swing also brings about an increase in the implied volatility, then a delta neutral-positive gamma strategy will profit from both events because positive gamma positions also usually have positive vega.

Returning to the main discussion, any of the three volatility views above can be held simultaneously with one of the three stock price views. An investor, for example, may feel strongly that the stock price and the stock volatility will both rise in the near future. Nine separate outlooks are therefore possible, so we have divided the options strategies that follow into nine categories such that each reflects an outlook for both stock price and stock volatility.

c. Risk and Return Preference

The third factor that motivates the strategy selection process is the individual investor's preference for risk and return. A speculative investor who expects both the price and the volatility of a stock to rise can implement a high risk and return strategy by establishing an options position with a large positive delta and vega. A more risk averse investor can assume less risk and receive less return by implementing a strategy that results in a position with lower delta and vega. Options thus provide the versatility to profit from all possible price and volatility outlooks, with or without the stock, and to simultaneously satisfy a broad range of risk and return preferences. Therefore, for each stock price and stock volatility outlook we further classify the strategies according to risk.

Figure 31 lists the basic options strategies that are discussed in the remainder of this chapter. The strategies within a cell reflect one of the nine possible combinations of stock price and stock volatility outlook, and are listed in order of decreasing risk. The center cell is empty because an investor who is uncertain about the future level of both price and volatility probably has no motivation to invest in either options or the underlying stock.

Figure 31. Options Strategy Matrix

	BULLISH STOCK OUTLOOK	NEUTRAL STOCK OUTLOOK	BEARISH STOCK OUTLOOK
INCREASING VOLATILITY OUTLOOK	1. Long ATM or ITM Call 2. Long Stock + Long ATM or OTM Put	1. Long Straddle 2. Long Strangle 3. Short Butterfly 4. Short Condor 5. Short ATM Horizontal Spread 6. Ratio Call Backspread 7. Ratio Put Backspread	1. Long ITM Put 2. Short Stock + Long OTM Call
NEUTRAL VOLATILITY OUTLOOK	1. Long Stock 2. Long Synthetic Stock 3. Vertical Bull Spread 4. Long Collar		1. Short Stock 2. Short Synthetic Stock 3. Vertical Bear Spread 4. Short Collar
DECREASING VOLATILITY OUTLOOK	1. Write ITM Put 2. Long Stock + Write OTM Call	1. Short Straddle 2. Short Strangle 3. Write OTM Call 4. Write OTM Put 5. Long Butterfly 6. Long Condor 7. Long ATM Horizontal Spread 8. Ratio Call Spread 9. Ratio Put Spread	1. Write ITM Call 2. Short Stock + Write OTM Put

Source: Smith Barney Inc./Salomon Brothers Inc.

2. Discussion of the Strategies

We now discuss in detail the options strategies listed in Figure 31. Each strategy is classified under one of the nine possible categories where each category reflects one of the three stock price outlooks and one of the three volatility outlooks. Within a given category the strategies are discussed in order of decreasing risk.

Some strategies cannot easily be confined to a single category. The flexibility and versatility of options allow them to meet many different objectives simply by varying their strike prices and times to expiration. For example, the parameters of the options used to implement the vertical bull spread in the bullish stock-neutral volatility cell can be chosen to satisfy any one of the three volatility outlooks. Similarly, the parameters of the options used to implement the long horizontal spread in the neutral stock-decreasing volatility cell can be chosen to satisfy any one of the three stock price outlooks. Strategies that can be classified under more than one category are duly noted in the following discussions.

The following information is provided for each strategy:

(1) Description: The type, series, and class of the options required to implement the strategy are given. Sample options are introduced and their prices and other parameters are used to illustrate the profit and loss characteristics of the strategy.

(2) Profit and Loss or Payoff Diagram: This diagram shows the profit or loss of each component and of the overall position as a function of the underlying stock price at expiration of the options.

(3) Profit and Loss Analysis: This analysis includes:

- Maximum Profit: The maximum gain from the strategy under the best possible scenario.
- Maximum Loss: The maximum loss from the strategy under the worst possible scenario.
- Breakeven Points: The price that the stock must reach at expiration for the strategy to yield zero profit or loss.
- Profit versus S^*: An expression which gives the profit or loss for any value of S^*, the stock price at expiration.
- Profit versus t^*, the time remaining to expiration: A comment on how the profits or losses of the position change as time passes and the options get closer to expiration. The change in profits as time passes is a function of the position theta.
- The profit and loss analysis will include equations for the first four quantities above. Also, simulated profits and losses are computed using the parameters of the options used as examples in 1), from assumed values of S^0, the stock price when the position is initiated, and from assumed values of S^*.

(4) Effects of Varying Option Parameters: The effects of varying the strike price, *K*, and the time to expiration, *t*, on the profit and loss characteristics and the risk of the strategy will be discussed. Varying these parameters customizes the strategy and allows it to satisfy many variations of the original investment objective and many risk and return preferences.

(5) Equivalent Positions and Synthetics: Often a strategy can be implemented with several different but equivalent combinations of options and the underlying stock. All of the significant equivalent positions are listed.

(6) Additional Comments: Comparison with other strategies, investor motivation, special features, additional risk considerations, and additional examples are given.

a. Bullish Stock Outlook-Neutral Volatility Outlook

The first category that we consider consists of the options strategies that are designed to produce positive returns when the price of the underlying stock increases, and the investor is uncertain of the direction of future realized and implied volatility. The positions used to implement these strategies should have positive delta to insure that the position value increases as the stock price increases. The positions should also have zero vega, if possible, to remove the risk of an unanticipated change in the implied volatility. Note however, that zero vega usually means zero gamma so the extra benefits from combining positive gamma with positive delta will not be obtained. The strategies include, in order of decreasing risk:

- Buy the stock
- Buy Synthetic Stock
- Vertical Bull Call or Put Spread
- Long Collar

Buy Stock

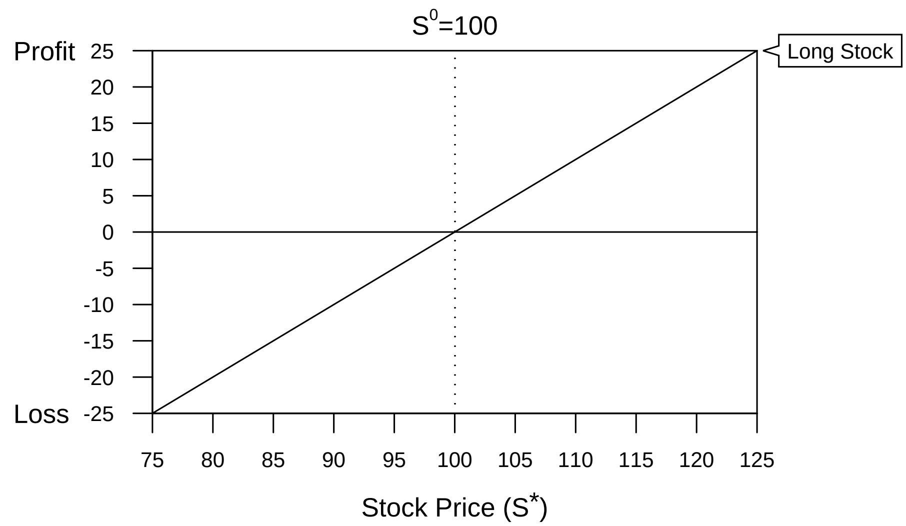
(1) Description: If an investor wants to profit from a rise in the price of a stock, then the simplest possible strategy is to buy the stock. Without options this is the only possible strategy. Often however, outright stock purchase is not practical because of unavailable funds, legal restrictions, or the need for prior approval. Options then provide many valuable alternatives to outright stock ownership.

Example:

Buy 100 shares of ZYX stock for $100 per share.

(2) Payoff Diagram: The payoff diagram graphically depicts the profit or loss of a portfolio of stock and options as a function of the underlying stock price. The payoff is measured at some time in the future, usually the expiration date of the options. Figure 32 is the payoff diagram for a long position in the stock. The horizontal or x-axis is S^*, the stock price some time after the stock is purchased. The vertical or y-axis is the profit or loss that results from a given value of S^*. Note that the price of the stock that results in zero profit is S^0, the purchase price of the stock. Thus, the profit or loss at some time in the future is simply $(S^* - S^0)$. Every \$1 increase in stock price results in a corresponding \$1 increase in net profit. The payoff line is therefore positively sloped at 45 degrees. Finally, to simplify the analysis we neglect the effects of commissions, margin payments, taxes, and dividends on profits. However, options investors should realize that these quantities represent real costs and can significantly reduce the profits of stock and options portfolios.

Figure 32. Payoff Diagram for Long Stock



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume the stock price increases to \$110 per share. In this and all subsequent analyses we compute the profit per share of stock or per option on a single share of stock. So we have that S^0 = \$100, and S^* = \$110.

Maximum Profit:	Unlimited	
Maximum Loss:	S^0	\$100
Breakeven Point:	$S^* = S^0$	\$100
Profit versus S*:	Profit = $(S^* - S^0)$	\$10
Profit versus t*:	Profit depends only upon S*	

(4) Effects of Varying Option Parameters: Strike price and time to expiration do not apply to a long stock position. The stock is bought or sold at its current market value and does not expire unless the issuing company ceases to exist.

(5) Equivalent Positions: Buy a call and write a put with the same *K* and *t*.

(6) Additional Comments: Buying stock is the riskiest strategy in this category. The stock owner loses \$1 per share for every \$1 decrease in the stock price and gains \$1 per share for every \$1 increase in the stock price, i.e., the delta of a long stock position is +1.

Buy Synthetic Stock

(1) Description: Buy a call option and write a put option on stock ZYX, each with strike price, *K*, equal to the current stock price, S^0, and with time to expiration, *t*.

Example:

Buy 1 ZYX Jun 100 Call contract for $987.50

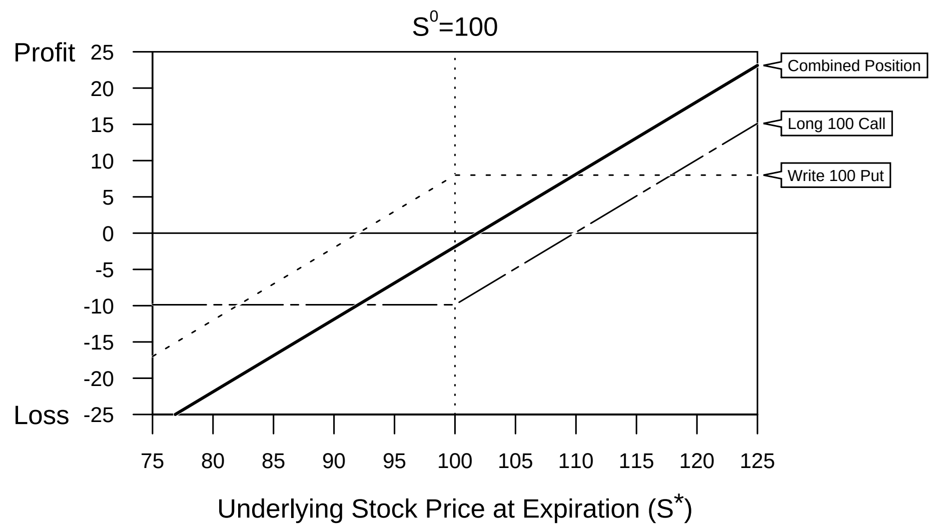
Write 1 ZYX Jun 100 Put contract for $800.00

Current price of ZYX stock is $100 per share

(Note: In this and all subsequent examples we compute option prices assuming that *t*, the time to expiration of the June contract, is 150 days, *r*, the risk free interest rate is 5% per year, and the volatility of the underlying stock is 35% per year. Also, we let *C* and *P* denote the prices of a call option and put option, respectively.)

(2) Payoff Diagram: See Figure 33.

Figure 33. Payoff Diagram for Long Call and Written Put with Same Strike Price and Time to Expiration



Source: Smith Barney Inc./Salomon Brothers Inc.

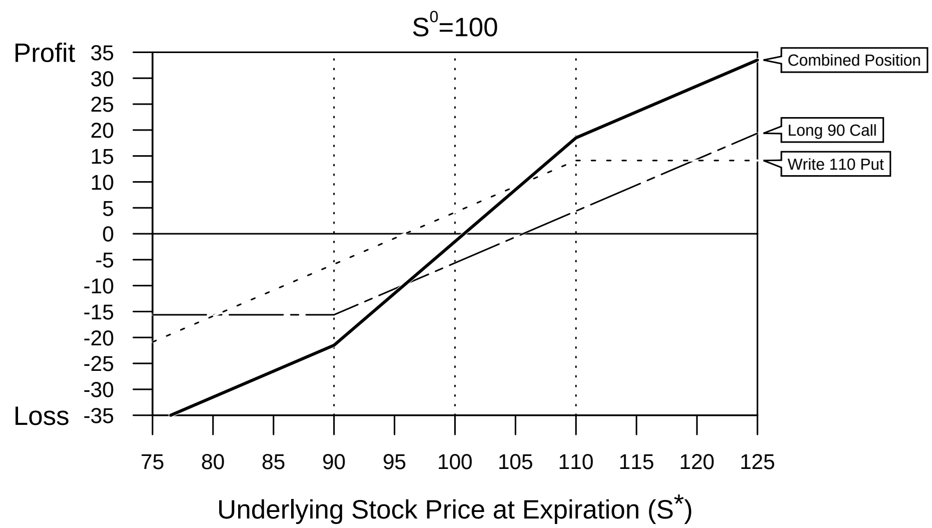
(3) Profit and Loss Analysis: Assume that S^*, the stock price at expiration of the options is $110.

Maximum Profit:	Unlimited	
Maximum Loss:	$(P - C) - S^0$	$101.875
Breakeven Point:	$S^* = K + C - P$	$101.875
Profit versus S*:	Profit=$(P - C) + (S^* - K)$	$8.125
Profit versus t*:	The call theta is slightly greater than the put theta, so profits decrease slightly as the options expire.	

(4) Effects of Varying Option Parameters: When the strike prices of both options are equal, delta is almost exactly +1 and the profits increase or decrease by $1 for every $1 increase or decrease in the stock price as shown in Figure 33. However, assume that both the call and the put are originally

struck \$10 ITM so the original delta is about 1.35. Then the call strike is (S^0 - 10) and the put strike is (S^0 + 10). If the stock finishes between the two strike prices, then the call finishes ITM with a profit of (S^* - K) = (S^* - S^0 + 10). The put also finishes ITM with a loss of (S^*- K) = (S^* - S^0 - 10). The net profit or loss is then 2(S^* - S^0). So if the two strikes are different and ITM, the delta of the position at expiration is +2, and profits increase or decrease by \$2 for every \$1 increase or decrease in the price of the underlying when S^* falls between the strikes. This case is shown in Figure 34. So the strategy can be made more bullish and riskier by splitting the strike prices such that both options are originally ITM. Note that if the call is struck ATM and the put is struck ITM, then profits increase by \$2 for every \$1 increase in the price of the underlying, but only decrease by \$1 for every \$1 decrease in the underlying. That is, at expiration delta is +2 if $S^* > S^0$, and delta is +1 if $S^* < S^0$.

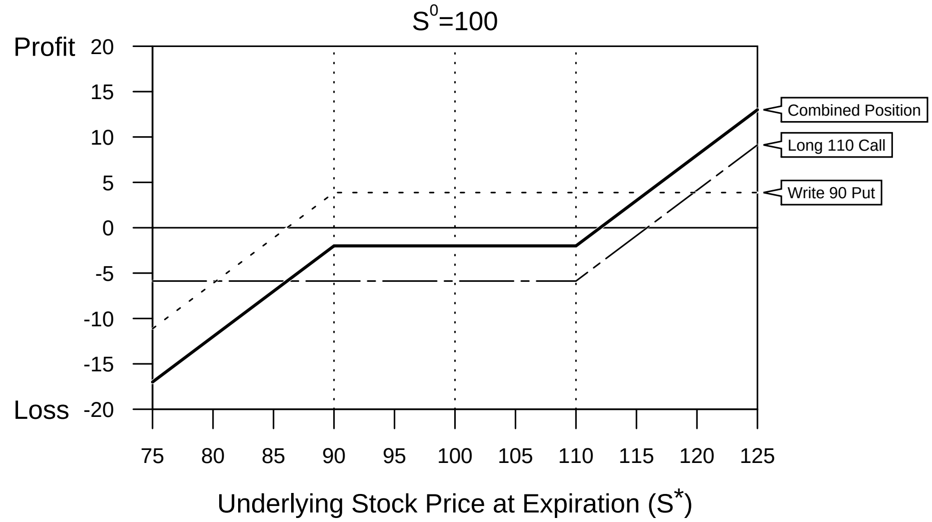
Figure 34. Payoff Diagram for Long ITM Call and Written ITM Put



Source: Smith Barney Inc./Salomon Brothers Inc.

Now assume that both the call and the put are originally OTM. If the stock finishes between the two strike prices in this case, then both options expire OTM and worthless, delta is zero, and profits are independent of the price of the underlying. This case is shown in Figure 35. So the strategy can be made less risky by splitting the strike prices such that both options are originally OTM. Note that if the call is struck ATM and the put is struck OTM, then profits increase by \$1 for every \$1 increase in the price of the underlying, but do not decrease at all as the price of the underlying decreases as long as S^* is greater than the put strike. That is, at expiration delta is +1 if $S^* > S^0$, and delta is 0 if $S^* < S^0$.

Figure 35. Payoff Diagram for Long OTM Call and Written OTM Put



Source: Smith Barney Inc./Salomon Brothers Inc.

As the time to expiration increases, the long call price increases more than the written put price, so profits decrease.

(5) Equivalent Positions: Buy the underlying stock

(6) Additional Comments: To see that this strategy is equivalent to buying the underlying stock when both strikes are the same, consider substituting 1 share of ZYX stock worth $100 with one long ZYX Jun 100 call and one written ZYX Jun 100 put. The position is theoretically initiated for (C - P) or $1.875. The remaining $98.125 is invested at the risk free rate of 5% for the 150 day lifetime of the options. If the stock price at expiration is $110 then the call is worth $10, the put is worthless, and the cash position is worth $100, the original strike price. The final option position is worth $110, the same as the equivalent stock position. If the stock price at expiration is $90 then the call is worthless, the put is assigned and the investor must buy stock worth $90 for $100, and the cash position is again worth $100. So again the final option position and equivalent stock position are the same and equal to one share of stock worth $90. In general, the cash position will be worth K and the options will be worth (S^* - K) for a net value of S^*, the same as the value of an equivalent position in the underlying stock. This equivalency is also apparent from the put-call parity relationship discussed in Chapter Three. There we used arbitrage arguments to show that a long call in combination with a written put is equivalent to borrowing the present value of the strike price and buying stock.

The example above illustrates how options can be used as a stock substitute. If an investor has a bullish stock outlook yet lacks the funds to buy the stock, he or she can theoretically buy the synthetic option equivalent for less than 2% of the cost of the stock. However, in reality, margin requirements significantly increase the cost of establishing the position. The entire call premium must be paid in full, and the entire proceeds of the put sale plus 20% of the underlying stock value must be deposited as initial margin. So the actual cost of establishing the synthetic position in the example above is ($9.875 + $20.00) = $29.875 and not $1.875. If the $28.00 in the margin account ($20.00 plus $8.00 proceeds of put sale) earns interest at less than the risk free rate, then the synthetic stock will underperform the actual stock. This example underscores the importance of considering margin as well as taxes, commissions, and other transaction costs when implementing equity options strategies. Nevertheless, the synthetic stock position is initially cheaper to establish than the long stock position which costs $50.

Finally, note that the above analyses assume that the underlying stock pays no dividends. Stock options are not payout protected which means that their value is not adjusted for dividend payments. Therefore, if a stock pays a dividend the synthetic (Call - Put) will only equal the value of the stock less the dividend at expiration.

We now digress to discuss three important considerations which apply to this and other equity options strategies.

a) The success and profitability of any equity strategy depend upon the accuracy of the stock outlook. The most clever and ingenious bullish strategy will not make money if the stock price declines. Two additional considerations with options are that the expected stock price movement must occur before the options expire, and strike prices must be chosen that produce sufficient profits at an acceptable level of risk.

b) Assignment Risk: The decision to exercise an option lies entirely with the owner. Therefore, the writer of an American style call or put must be aware that exercise can in theory occur any time during the lifetime of the options and that early exercise and assignment can prevent a strategy from meeting its objective. The likelihood of early assignment can be assessed for the following three cases: (See also Section A-7 of Chapter Three)

American Call-No Dividends: An American call option on a stock that does not pay dividends will never be exercised early.

American Call-Pays Dividends: A deep ITM American call option that has very little time value and whose underlying stock pays dividends may be exercised early on the day before the ex-dividend date if the present value of the dividends exceeds the present value of the interest that can be earned on the strike price of the call.

American Put: An American put option may be exercised early whether it pays dividends or not. A put on a non-dividend paying stock may be exercised early if the negative carrying cost or interest foregone on the strike price is sufficiently large. A put on a dividend paying stock may be exercised early when the present value of the interest earned on the strike price exceeds the present value of the dividends.

c) Time Decay: Recall from Chapter Three that the value of an option at any time prior to expiration consists of two components: the intrinsic value which is the larger of 0 or (S - K) for calls and the larger of 0 or (K - S) for puts; and the time value, $V(t)$. The time value is greatest for an ATM option, and decreases symmetrically as the option goes ITM or OTM. As discussed in Chapters Three and Four, the time value decreases as the option expires, and theta, the magnitude of the decay, is greater for calls and increases rapidly during the last few weeks prior to expiration for both calls and puts. At expiration the time value is zero and the price of the option declines by the full amount $V(t)$. Therefore, the profits of a long option position decrease by the same amount. The profits of a portfolio with written options increase by the same amount at expiration. Therefore, the payoff diagrams and profit and loss analyses at expiration depict the minimum profits for a long option position and the maximum profits for a written option position.

Figures 36 and 37 show the time decay of the ZYX Jun 100 Call and Put.

Figure 36. Value of the ZYX Jun 100 Call versus *t, the Time Remaining to Expiration**

t* (Days)	C	$ Decrease	% Decrease	Cumulative % Decrease
150	9.875			
120	8.750	1.125	11.4	11.4
90	7.500	1.250	14.3	24.0
60	6.000	1.500	20.0	39.2
30	4.250	1.750	29.2	57.0
20	3.375	0.875	20.6	65.8
10	2.375	1.000	29.6	75.9
5	1.688	0.687	28.9	82.9
2	1.062	0.626	37.1	89.2
1	0.750	0.312	29.4	92.4

Source: Smith Barney Inc./Salomon Brothers Inc.

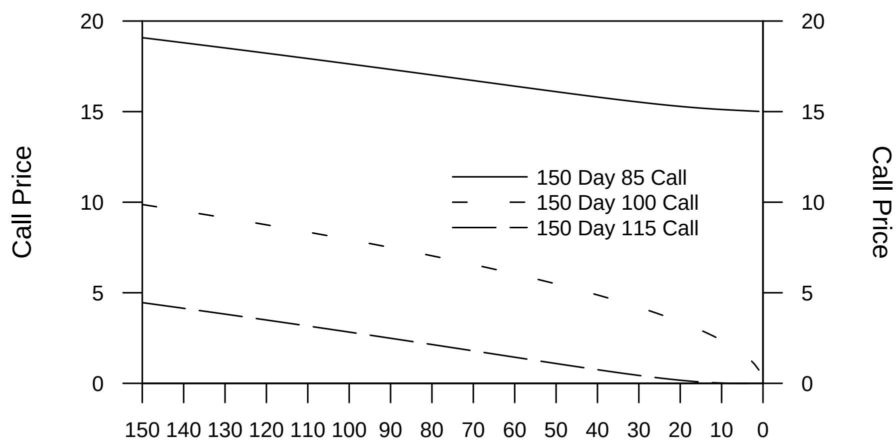
Figure 37. Value of the ZYX Jun 100 Put versus *t, the Time Remaining to Expiration**

t* (Days)	P	$ Decrease	% Decrease	Cumulative % Decrease
150	8.000			
120	7.250	0.750	9.4	9.4
90	6.375	0.875	12.1	20.3
60	5.250	1.125	17.6	34.4
30	3.875	1.375	26.1	51.6
20	3.125	0.750	19.4	60.9
10	2.250	0.875	28.0	71.9
5	1.625	0.625	27.8	79.7
2	1.000	0.625	38.5	87.5
1	0.750	0.250	25.0	90.6

Source: Smith Barney Inc./Salomon Brothers Inc.

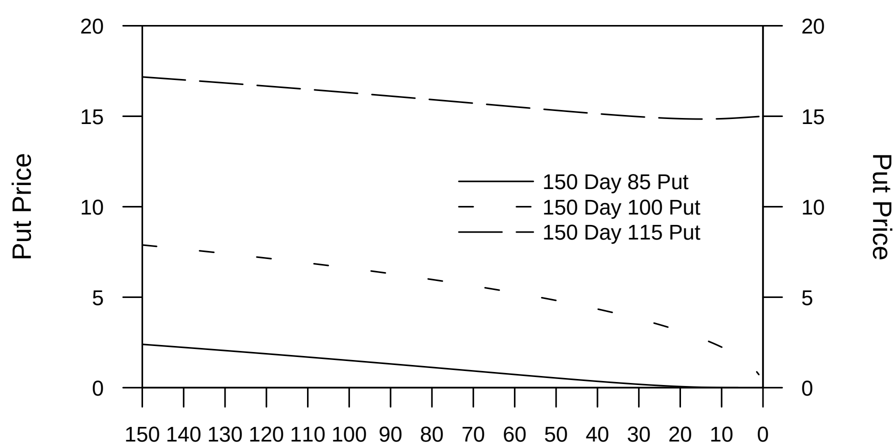
Figures 38 and 39 show the same information graphically for the ZYX Jun 85, 100, and 115 calls and puts.

Figure 38. Value of the ZYX Jun 85, 100, and 115 Call Options versus *t, the Time Remaining to Expiration**



Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 39. Value of the ZYX Jun 85, 100 and 115 Put Options versus *t, the Time Remaining to Expiration**



Source: Smith Barney Inc./Salomon Brothers Inc.

We now return to the discussion of the strategies in the Bullish Stock Outlook-Neutral Volatility Outlook category.

Vertical Bull Call or Put Spread

This strategy belongs to the general category known as spreads. A spread involves buying one asset and selling another with similar price behavior. The long side profits from a price increase and the short side profits from a price decrease. So when one side shows a profit the other side shows an almost equal loss. Spreads are used to create low risk positions that generate profits when the long asset is undervalued and the short asset is overvalued.

Options spreads involve simultaneously buying options of a given class and writing options of the same class but different series. A vertical bull call spread involves buying a call with a given strike price K_1 and writing a call with a higher strike price K_2. Both calls are on the same underlying stock and have the same time to expiration, t. The spread is called a long or bull spread when the more expensive call is bought and the less expensive call is written, and the position is established for a debit. Otherwise, the spread is called a short or bear spread. The spread is referred to as vertical because it involves options with different strike prices. Vertical spreads are also called perpendicular, money, or price spreads.

(1) Description: Buy a call option on stock ZYX with strike price K_1 and write a call option on stock ZYX with a higher strike price K_2. Both options have the same time to expiration, t.

Example:

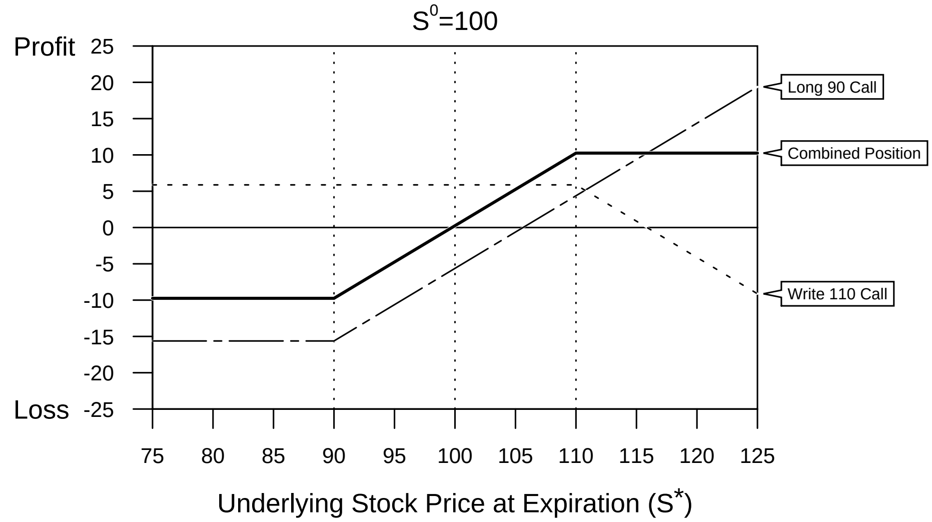
Buy 1 ZYX Jun 90 Call contract for $1562.50

Write 1 ZYX Jun 110 Call contract for $587.50

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 40.

Figure 40. Payoff Diagram for Vertical Bull Call Spread



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume that S^* = \$105

Maximum Profit:	$(K_2 - K_1) + (C_2 - C_1)$		\$10.25
Maximum Loss:	$C_1 - C_2$		\$9.75
Breakeven Point:	$S^* = K_1 - (C_2 - C_1)$		\$99.75
Profit versus S*:	Profit = $C_2 - C_1$	for $S^* \leq K_1$	
	Profit = $(S^* - K_1) + (C_2 - C_1)$	for $K_1 < S^* \leq K_2$	\$5.25
	Profit = $(K_2 - K_1) + (C_2 - C_1)$	for $S^* > K_2$	
Profit versus t*:	Profits increase slightly as the options expire because theta of the written call is slightly greater (more negative) than theta of the long call. Position theta is slightly positive.		

(4) Effects of Varying Option Parameters: If the stock price at expiration is between the strike prices, then profits increase as K_1 and K_2 both decrease and both calls become more ITM. However, this also decreases the maximum profit and increases the maximum loss. If the stock price at expiration is above the higher strike K_2, then the maximum profit increases as the strikes become farther apart. So if the stock outlook is very bullish, then decrease the strike of the long call and increase the strike of the written call. If the stock outlook is less bullish then decrease the strikes of both calls. The strategy produces optimal results when the stock price at expiration is close to the strike price of the written call, K_2.

The delta of the position represented by the example is about 0.33 and increases as K_1 decreases and as K_2 either increases or stays the same. The vega and gamma are slightly negative.

This strategy also satisfies a long volatility outlook if the long call is ATM and the written call is OTM because the spread then has positive vega. Likewise, the strategy satisfies a short volatility outlook if the long call is ITM and the written call is ATM because then the spread has negative vega.

As the time to expiration increases, the difference between the two call prices is almost constant, so profits are independent of t.

(5) Equivalent Positions:

Buy stock, buy put with K_1, and write call with K_2

Buy put with K_1 and write put with K_2.

(6) Additional Comments: The vertical bull call spread is a strategy whose payoff is almost identical to that of the underlying stock when the stock price at expiration falls somewhere between the strike prices of the two options. If the stock price at expiration is below K_1 or above K_2, profits and losses are capped. So the strategy is similar to buying a call option and paying for it with the upside profit potential.

Note from (5) that the same strategy can be implemented with put options and is then called a vertical bear put spread. In this case the maximum profit or ceiling is $(P_2 - P_1)$ and the maximum loss or floor is $(K_2 - K_1) + (P_1 - P_2)$, and the payoff characteristics of the put and call spreads are almost identical. However, since the long put is OTM it costs less than the ITM written put, so the put spread is initiated for a credit in contrast to the call spread.

To make the put spread satisfy a long volatility outlook, use an ATM long put and an ITM written put. To make the put spread satisfy a short volatility outlook, use an OTM long put and an ATM written put.

Long Collar

(1) Description: Buy an OTM put option contract with strike price K_1 and write an OTM call option contract with a higher strike price K_2 for every 100 shares of ZYX stock owned. Both options have the same time to expiration, t.

Example:

Buy 1 ZYX Jun 90 Put contract for $387.50

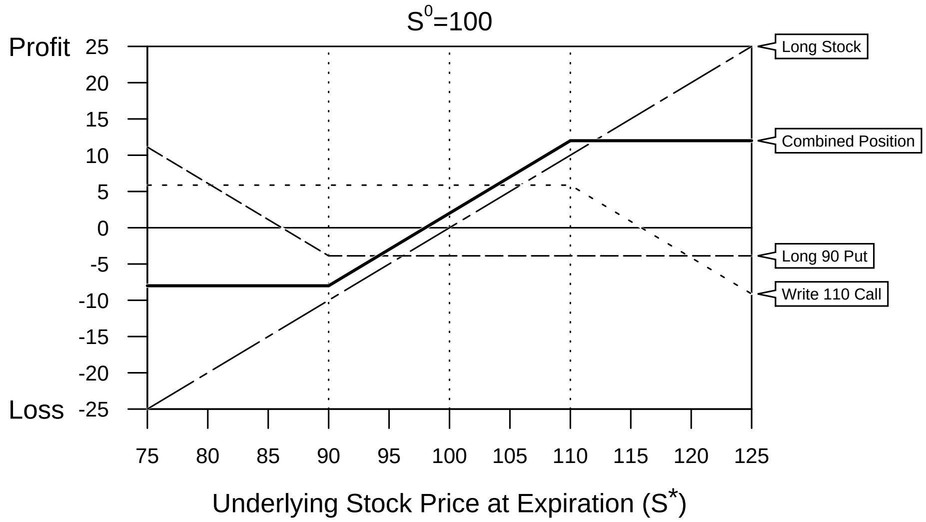
Write 1 ZYX Jun 110 Call contract for $587.50

We own 100 shares of ZYX stock

Current price of ZYX is $100 per share.

(2) Payoff Diagram: See Figure 41.

Figure 41. Payoff Diagram for the Long Collar



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume that S^* = $105

Maximum Profit:	$(K_2 - S^0) + (C - P)$		$12.00
Maximum Loss:	$(K_1 - S^0) + (C - P)$		$8.00
Breakeven Point:	$S^* = S^0 - (C - P)$		$98.00
Profit versus S*:	Profit = $(K_1 - S^0) + (C - P)$	for $S^* \le K_1$	
	Profit = $(S^* - S^0) + (C - P)$	for $K_1 < S^* \le K_2$	$7.00
	Profit = $(K_2 - S^0) + (C - P)$	for $S^* > K_2$	
Profit versus t*:	Profits increase as the options expire because the position theta is slightly positive.		

(4) Effects of Varying Option Parameters: This strategy pays $(C - P)$ more than the underlying stock when S^* is between the strike prices. This premium is relatively constant as long as the strikes are the same distance from the initial stock price, S^0. So the only way to increase the premium is to buy a cheaper or more OTM put or to write a more expensive or ITM call. However, the former increases the maximum loss and the latter decreases the maximum gain.

As the time to expiration increases, the call price increases more than the put price so total profits increase.

(5) Equivalent Positions:

Buy call with K_1 and write call with K_2

Buy put with K_1 and write put with K_2

(6) Additional Comments: This strategy is called a collar because it creates both an upper and a lower bound on the profits of the long stock. Note from (5) that it is equivalent to the vertical bull call and bear put spreads

discussed earlier. The strategy can be viewed as insuring the long stock with a put and financing the insurance premium in part with the proceeds from the written call. However, the price of the cheaper insurance is the loss of profits if S^* is greater than the call strike. When the call and put are struck at the same distance from the current stock price, the position is established for a credit. Often, the put is struck less OTM until its price equals that of the call, and the strategy is then referred to as a zero-cost collar. A zero-cost collar offers more downside protection and reduces the maximum possible loss.

The collar is implemented instead of the vertical call or put spread when the investor already owns stock and seeks to cap profit and loss and reduce the risk of the long stock position. Like the vertical spread, the collar can also satisfy long and short volatility outlooks by using an ATM put/OTM call or an OTM put/ATM call, respectively.

b. Bullish Stock Outlook-Increasing or Long Volatility Outlook

The second category of options strategies that we discuss consists of those designed to produce positive returns when both the price of the underlying stock and the stock volatility increase. The positions used to implement these strategies should have positive delta to insure that the position value increases as the stock price increases. The positions should also have positive vega to insure that the position value also increases as the implied volatility increases. Since positive vega usually means positive gamma, the extra benefits from combining positive gamma with positive delta are obtained.

The strategies include, in order of decreasing risk:

- Long ITM Call
- Long Stock plus Long OTM Put

Long ITM Call

(1) Description: Buy a call option on stock ZYX with strike price K less than the current stock price and with time to expiration, t.

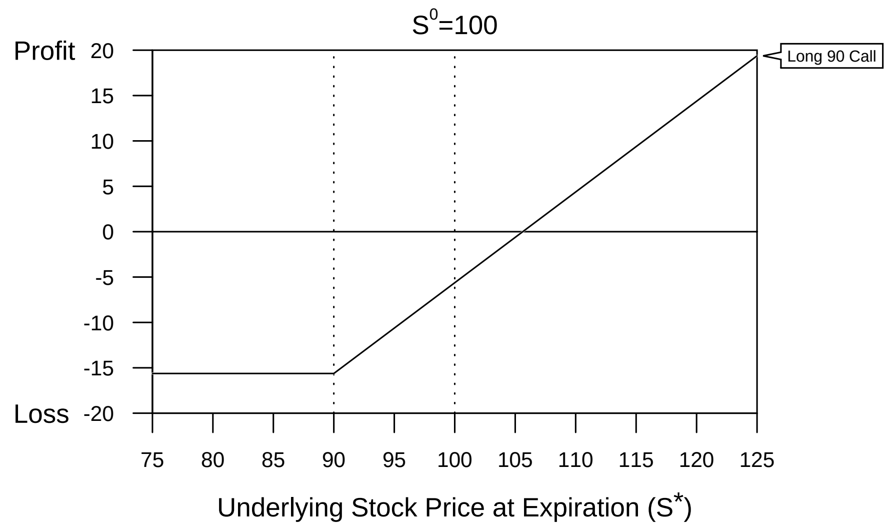
Example:

Buy 1 ZYX Jun 90 Call contract for $1562.50

Current price of ZYX stock is $100 per share

(2) Payoff Diagram: See Figure 42.

Figure 42. Payoff Diagram for Long ITM Call



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume that S^* = \$115

Maximum Profit:	Unlimited		
Maximum Loss:	C		\$15.625
Breakeven Point:	S* = K + C		\$105.625
Profit versus S*:	Profit = -C	for S* ≤ K	
	Profit = S* - K - C	for S* > K	\$9.375
Profit versus t*:	Profits decrease as the call option expires because the call theta is negative.		

(4) Effects of Varying Option Parameters: The payoff of this strategy is less than that of owning the underlying stock by an amount equal to (K - S^0 + C), or \$5.625, when S^* is greater than K. In return, losses are limited to -C if S* decreases below K. As K decreases and the call becomes more ITM, the underperformance relative to the long stock decreases, but the maximum loss increases. The strategy becomes more bullish because profits increase for a fixed increase in the stock price. The strategy also becomes riskier as the call strike decreases because losses increase for a fixed decrease in the stock price and because the call delta increases. Buying a call option is equivalent to buying the underlying stock in combination with an insurance policy.

As the time to expiration increases, the call price increases and profits decrease.

(5) Equivalent Positions: Buy stock and buy OTM put with strike K

(6) Additional Comments: The long call strategy allows a bullish investor to profit from an increase in the stock price while limiting losses to the call premium if the stock price actually declines. Consider one type of call buyer whose goal is to implement the strategy as a substitute for buying the stock. Instead of buying a share of ZYX for \$100, the investor buys a ZYX Jun 90

call for $15.625 and invests the remaining $84.375 at 5% for the 150 day life of the option. If the price of ZYX increases to $115 at expiration, then the option is worth $25 and the cash account is worth $86.00 for a total of $111. If the call buyer had purchased the stock, then the position would be worth $115. The $4 difference is the cost of insuring that the loss does not exceed the price of the call.

The second type of call buyer is the speculator whose objective is to maximize total wealth if the stock price increases. This buyer invests the entire $100 in 6 ZYX Jun 90 calls and invests the residual $6.25 in cash. If the price of ZYX increases to $115 at expiration, then the 6 options are worth $150 and the cash account is worth $6.38 for a total of $156.38. The speculator has thereby used the leverage that call options offer to increase his or her wealth by over 56% with only a 15% increase in the underlying stock price. If the underlying increases by 25% then the option position rises by over 116%. The key to this performance is that the options position earns $6 for every $1 that the stock finishes above the strike price. The price that the speculator pays for these large potential gains is total loss if the stock price finishes at or below the strike price. So a speculator will invest everything in call options and maximize the position delta while an equity investor will invest only that amount which will return $1 for every $1 increase in the stock at expiration.

Note that as the strike price decreases and the call becomes more ITM, delta increases but gamma and vega decrease slightly. Therefore, we sacrifice some gains from an increase in volatility for additional gains from an increase in stock price.

Long Stock Plus Buy OTM Put

(1) Description: Buy a put option contract with strike price K less than the current stock price and with time to expiration, t, for every 100 shares of ZYX stock owned.

Example:

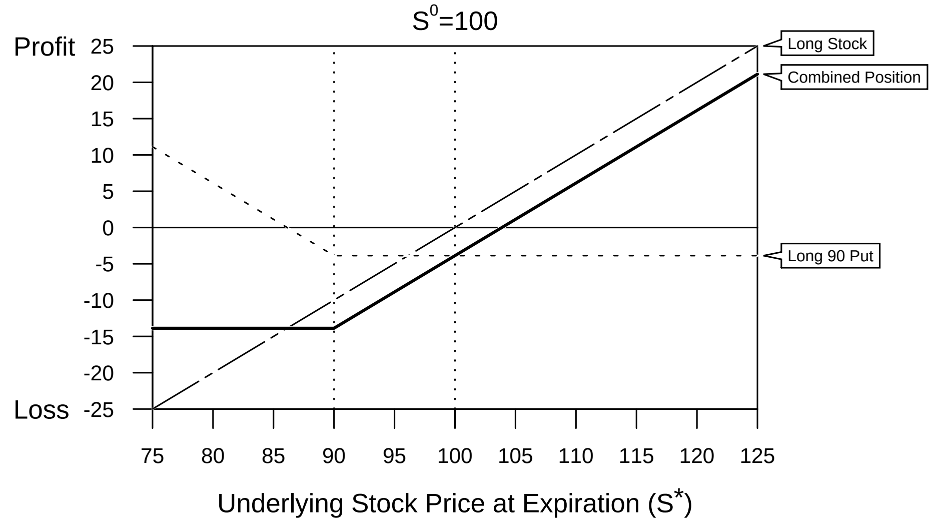
Buy 1 ZYX Jun 90 Put contract for $387.50

We own 100 shares of ZYX stock

Current price of ZYX is $100 per share

(2) Payoff Diagram: See Figure 43.

Figure 43. Payoff Diagram for Long Stock and Long OTM Put



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume that S^* = \$110

Maximum Profit:	Unlimited		
Maximum Loss:	$S^0 - K + P$		\$13.875
Breakeven Point:	$S^* = S^0 + P$		\$103.875
Profit versus S*:	Profit = $K - S^0 - P$	for $S^* \le K$	
	Profit = $S^* - S^0 - P$	for $S^* > K$	\$6.125
Profit versus t*:	Profits decrease as the option expires		

(4) Effects of Varying Option Parameters: The payoff of this strategy is less than that of owning the underlying stock by an amount equal to the put premium when the stock price at expiration is greater than the strike price. However, losses are limited to (S^0 - K + P) or \$13.875 in the example when the final stock price is less than or equal to the strike price. So the position will always be worth at least (K - P) or \$86.125 no matter how much the stock price decreases. As K decreases and the put becomes more OTM, the underperformance relative to the long stock decreases because the put becomes cheaper, but the maximum loss increases. The strategy becomes more bullish because profits increase for a fixed increase in the stock price. The strategy also becomes riskier as the put strike decreases because losses increase for a fixed decrease in the stock price and because delta increases.

As the time to expiration increases, the put price increases and profits decrease.

(5) Equivalent Positions: Buy ITM call with strike price K.

(6) Additional Comments: From (5) we see that this strategy is the same as buying a naked or uncovered call option. In fact, combining a put option with a share of stock converts the share into a call option until the option expires. The put option is equivalent to an insurance policy on the stock because the stock will never be worth less than the strike price of the put.

The difference between the initial stock price and the strike price is the deductible. The deductible decreases as the strike increases, but the put premium or the cost of insurance increases.

The strategy is still bullish because it profits from an increase in the stock price. However, it differs from outright stock ownership by providing protection against loss. Therefore it is amenable to more risk averse equity investors who are willing to sacrifice upside returns for downside protection.

c. Bullish Stock Outlook-Decreasing or Short Volatility Outlook

The third category of options strategies that we discuss consists of those designed to produce positive returns when the price of the underlying stock increases and the when the stock volatility decreases. The positions used to implement these strategies should have positive delta to insure that the position value increases as the stock price increases. The positions should also have negative vega to insure that the position value also increases as the implied volatility decreases. However, negative vega usually means negative gamma which reduces the profits of positive delta strategies.

The strategies include, in order of decreasing risk:

- Write ITM Put
- Long Stock plus Write OTM Call

Write ITM Put

(1) Description: Write a put option on stock ZYX with strike price K greater than the current stock price and with time to expiration, t.

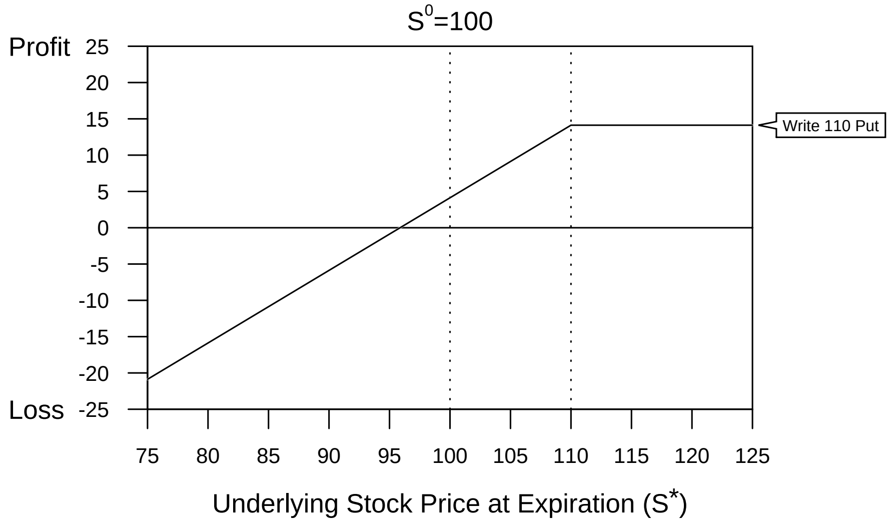
Example:

Write 1 ZYX Jun 110 Put contract for $1,412.50

Current price of ZYX stock is $100 per share

(2) Payoff Diagram: See Figure 44.

Figure 44. Payoff Diagram for Written ITM Put



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume that S^* = \$110

Maximum Profit:	P		\$14.125
Maximum Loss:	(P - K)		\$95.875
Breakeven Point:	S* = K - P		\$95.875
Profit versus S*:	Profit = (S* - K) + P	for S* < K	
	Profit = P	for S* ≥ K	\$14.125
Profit versus t*:	Profits increase as the put option expires because theta of the written put is positive.		

(4) Effects of Varying Option Parameters: The advantage of this strategy is that the payoff exceeds that of owning the underlying stock by an amount (S^0 - K + P) when $S^* < K$. The disadvantage is that profits are capped at P if S^* is greater than K. As K increases and the put becomes more ITM, the additional payoff decreases but the maximum profit increases. The strategy becomes more bullish because higher profits require a larger increase in the stock price. The strategy also becomes riskier because losses are greater for a given decrease in the stock price and delta increases. Writing a put option is equivalent to selling an owner of the stock an insurance policy. The writer keeps the insurance premium under all conditions but must also pay for the loss if the stock price at expiration is less than the strike price.

As the time to expiration increases, the put price increases and profits increase.

(5) Equivalent Positions: Buy stock and write call.

(6) Additional Comments: Put writing is a bullish-neutral strategy which should be implemented with caution. If the stock price increase is large or if the put is not far enough ITM, then the writer incurs an opportunity cost because profits are less than for an equivalent position in the stock. If the

stock price declines, the writer's loss is mitigated only by the put premium. The strategy produces optimal results when the stock price at expiration is equal to or slightly greater than the strike price. So the put writer should select a strike that is close to the price at which the stock is expected to finish. If the outlook is accurate the position will have higher profits than the equivalent long stock or long call positions. The ITM put writer is also subject to early assignment especially if the stock price initially declines.

Another motivation for writing naked puts is to acquire stock below its current market price. Say an investor feels that ZYX stock is too expensive at $100 a share but is fairly priced at $90. If the investor writes a ZYX 95 put for $5.60 and the stock is below $95 at expiration, then the put writer will be assigned and forced to buy the stock at $95. However, with the put premium the actual cost of the stock is less than $90. Writing naked puts to acquire stock insures that the stock purchase price is (K - P).

If the put option expires OTM, the investor will not be assigned, but will still have earned the entire put premium. If the stock price at expiration is $85, the investor must buy stock worth $85 for (95-5.60) = $89.40. However, the investor is still better off than if he or she had purchased the actual stock at $90.

Naked put writing is then a useful strategy for acquiring stock below the current market value. The put is usually ATM or OTM so the delta is less than for the ITM strategy and correspondingly less bullish. However, the strategy is still bullish because it satisfies the investor's goal to buy stock. Note that as the strike price increases and the put becomes more ITM, delta increases but vega becomes less negative. Therefore, we sacrifice some gains from a decrease in volatility for additional gains from an increase in stock price.

Long Stock Plus Write OTM Call

(1) Description: Write a call option contract with strike price K greater than the current stock price and with time to expiration, t, for every 100 shares of ZYX stock owned.

Example:

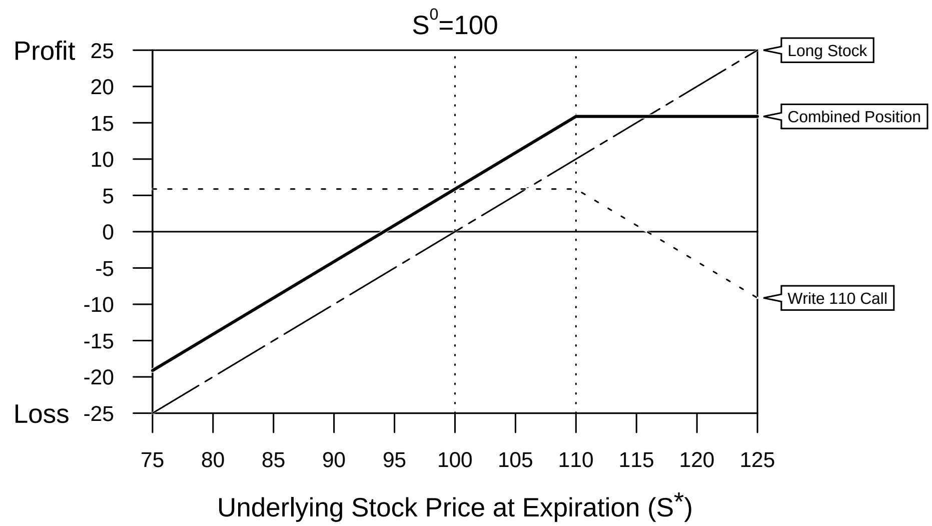
Write 1 ZYX Jun 110 Call contract for $587.50

We own 100 shares of ZYX stock

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 45.

Figure 45. Payoff Diagram for Long Stock and Written OTM Call



Source: Smith Barney Inc./Salomon Brothers Inc.

3) Profit and Loss Analysis: Assume that S^* = \$105

Maximum Profit:	$K - S^0 + C$		\$15.875
Maximum Loss:	$C-S^0$		\$94.125
Breakeven Point:	$S^* = S^0 - C$		\$94.125
Profit versus S*:	Profit = $S^* - S^0 + C$	for $S^* \leq K$	\$10.875
	Profit = $K - S^0 + C$	for $S^* > K$	
Profit versus t*:	Profits increase as the option expires		

(4) Effects of Varying Option Parameters: This strategy is equivalent to writing an ITM put option. The payoff exceeds that of owning the underlying stock by the call premium when S^* is less than K. However, profits are capped at $(K - S^0 + C)$ if S* is greater than K. As K increases and the call becomes more OTM, the additional payoff decreases but the maximum profit increases. The strategy becomes more bullish because higher profits require a larger increase in the stock price. The strategy also becomes riskier because losses become greater for a given decrease in the stock price and the position delta increases.

As the time to expiration increases, the call price increases and profits increase.

(5) Equivalent Positions: Write ITM Put

(6) Additional Comments: From (5) we see that this strategy is the same as writing a naked or uncovered put option. In fact, writing a call option against a share of stock converts the share into a written put option until the option expires. The strategy then is equivalent to selling an insurance policy. Like naked put writing the strategy is bullish-neutral and should be implemented with caution. If the stock price finishes higher than $(K$ + C), then the covered call writer incurs an opportunity cost because profits are less

than for the stock by itself. However, if the stock price declines, the losses are always reduced by the price of the call.

The primary goal of covered call writers is to obtain additional income from owning stock. The strategy outperforms that of long stock as long as the stock price at expiration is below $(K + C)$.

Another motivation for writing covered calls is to sell stock above the current market price. Say an investor feels that ZYX stock is too cheap at \$100 a share, but would be willing to sell at \$110. If the investor writes a ZYX 105 call for \$7.70 and the stock price is above \$105 at expiration, then the call writer will be assigned and forced to sell the stock at \$105. However, with the call premium, the actual sale proceeds are \$112.70. Writing covered calls to sell stock insures a sale price of at least $(K + C)$.

If the call expires OTM, the investor will not be assigned, but will still have earned the call premium. If the stock price at expiration is \$115, the investor must sell stock worth \$115 for \$112.70. However, the investor is still better off than if he or she had sold the actual stock when it was \$110. Note that as the strike price increases and the call becomes more OTM, delta increases but vega becomes less negative. Therefore, we sacrifice some gains from a decrease in volatility for additional gains from an increase in the stock price.

d. Bearish Stock Outlook-Neutral Volatility Outlook

The fourth category of options strategies that we consider consists of those designed to produce positive returns when the price of the underlying stock decreases, and the investor is uncertain of the direction of future realized and implied volatility. The positions used to implement these strategies should have negative delta to insure that the position value increases as the stock price decreases. The positions should also have zero vega, if possible, to remove the risk of an unanticipated change in the implied volatility. Note however, that zero vega usually means zero gamma so the extra benefits from combining positive gamma with negative delta will not be obtained.

The strategies include, in order of decreasing risk:

- Short the stock
- Short Synthetic Stock
- Vertical Bear Call or Put Spread
- Short Collar

Short Stock

(1) Description: If an investor seeks to profit from a decline in the price of a stock, then the simplest possible strategy is to short sell the stock. Without options this is the only possible strategy. However, shorting stock is not

always practical. First, the shares must be available for borrowing. Second, shorting is expensive because the entire proceeds of the sale must be deposited with the broker, and an additional 50% of the sale proceeds must be deposited as margin. The seller must also pay any dividends to the original owner. Finally, in the United States, the stock can only be sold at a price higher than the last trade price (an uptick), or at a price equal to the last trade price, but higher than the last trade at a different price (a zero-plus tick). Options, as a substitute for short stock, offer many economically favorable alternatives to outright short selling.

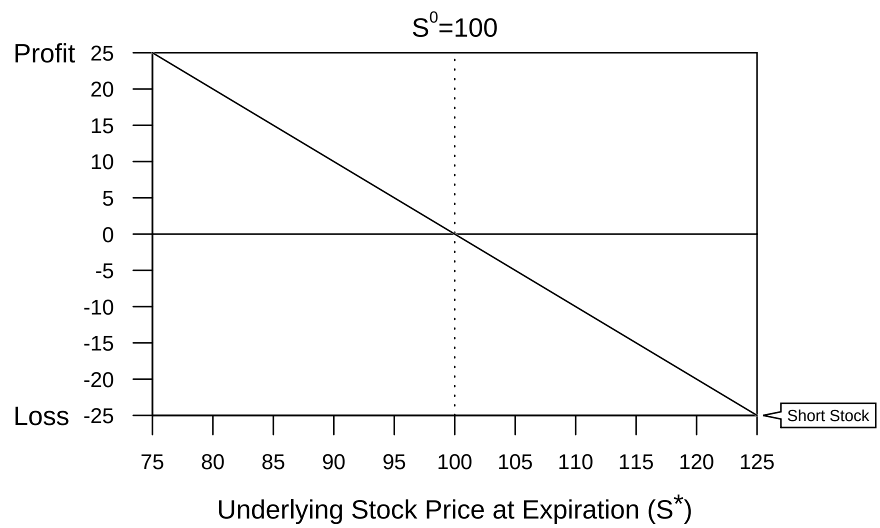
Example:

Short sell 100 shares of ZYX stock.

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 46.

Figure 46. Payoff Diagram for Short Stock



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = $90

Maximum Profit:	S^0	$100
Maximum Loss:	Unlimited	
Breakeven Point:	$S^* = S^0$	$100
Profit versus S*:	Profit = $(S^0 - S^*)$	$10
Profit versus t*:	Profit depends only upon S*	

(4) Effects of Varying Option Parameters: Strike price and time to expiration do not apply to a short stock position.

(5) Equivalent Positions: Write call and buy put.

(6) Additional Comments: Shorting stock is the riskiest strategy in this category. Delta is -1 and the seller of the stock suffers the entire loss when the stock price increases and reaps the entire reward when the stock price decreases. Shorting stock is riskier than buying stock because the maximum possible loss is unlimited.

Short Synthetic Stock

(1) Description: Buy a put option contract and sell a call option contract on stock ZYX, each with strike price K equal to the current stock price S^0, and with time to expiration, t.

Example:

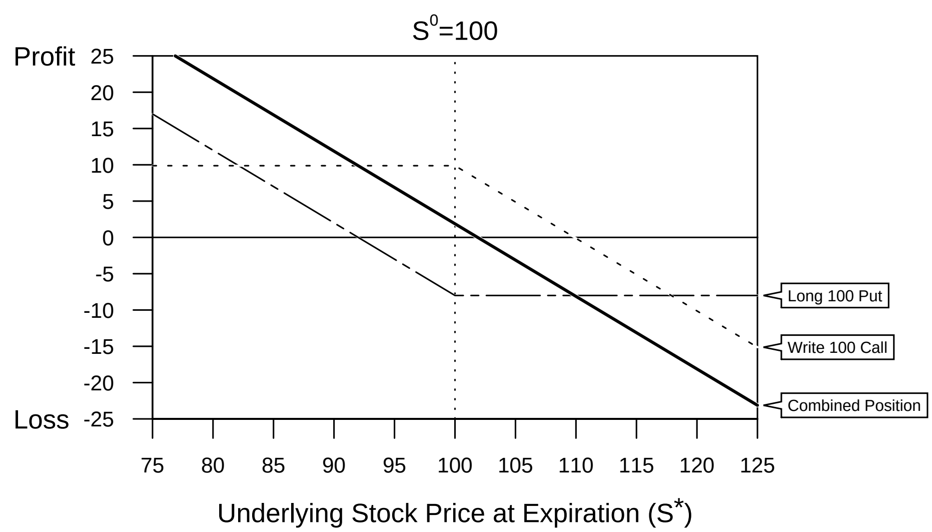
Buy 1 ZYX Jun 100 Put contract for $800.00

Write 1 ZYX Jun 100 Call contract for $987.50

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 47.

Figure 47. Payoff Diagram for Long Put and Written Call with Same Strike Price



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume that S^* = $110

Maximum Profit:	K + (C - P)	$101.875
Maximum Loss:	Unlimited	
Breakeven Point:	S* = K + (C - P)	$101.875
Profit versus S*:	Profit = (K - S*) + (C - P)	$11.875
Profit versus t*:	Profits increase as the options expire because the position theta is positive.	

(4) Effects of Varying Option Parameters: This position is the analogue to the long synthetic stock position which consists of a long call and a written put. If both strike prices are the same, then profits increase or decrease by $1 for every $1 decrease or increase in the price of the underlying at expiration. The strategy can be made more bearish and risky by splitting the strikes such that both options are originally ITM. Then profits at expiration increase or decrease by $2 for every $1 decrease or increase in the price of the underlying when S^* falls between the strikes.

The strategy can be made less risky by splitting the strikes such that both options are originally OTM. Then profits are independent of the price of the underlying when S^* falls between the strikes.

(5) Equivalent Positions: Short the underlying stock

(6) Additional Comments: As mentioned above, when stock is shorted the entire proceeds of the sale are held as collateral by the broker, and the borrower must deposit an additional 50% of the proceeds as initial margin. So shorting 1 share of ZYX stock worth $100 initially costs $50, the same as establishing a long position. For the synthetic position, the investor must pay the entire $8.00 put premium in full and deposit the $9.875 proceeds of the call sale as well as 20% of the underlying stock price ($20.00) as initial margin. So establishing the $100 synthetic short stock position initially costs $28.00 which is considerably less than the cost of the actual short stock position. Also, the options investor does not have to worry about the availability of the stock for borrowing or the uptick rule.

This strategy has the same risk and return profile as outright short selling. However, as pointed out above, the risk can be increased or decreased by using ITM or OTM options, respectively.

Vertical Bear Call or Put Spread

(1) Description: This strategy involves selling the vertical bull call or bear put spread. So buy a call option on stock ZYX with strike price K_2 and write a call option with a lower strike price K_1. Both options have the same time to expiration, t.

Example:

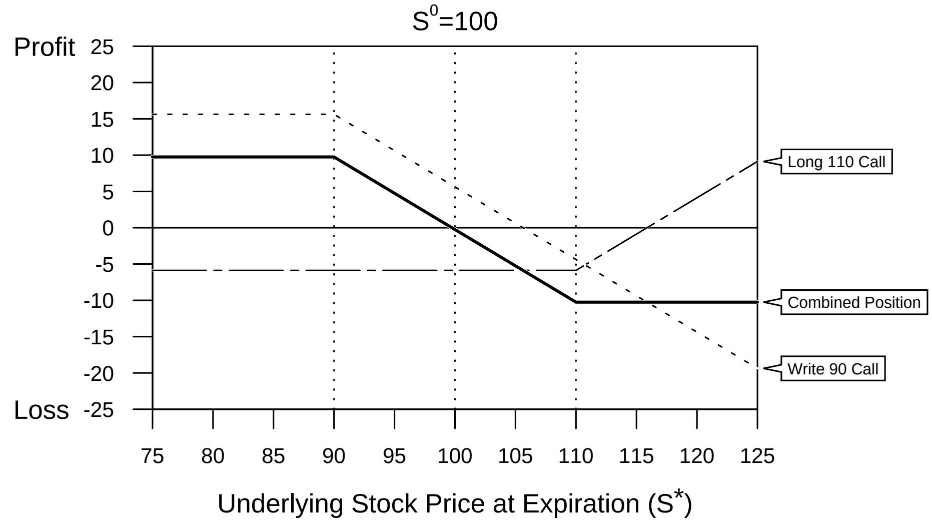
Buy 1 ZYX Jun 110 Call contract for $587.50.

Write 1 ZYX Jun 90 Call contract for $1562.50.

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 48.

Figure 48. Payoff Diagram for Vertical Bear Call Spread



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume that $S^* = \$95$

Maximum Profit:	$C_1 - C_2$		\$9.75
Maximum Loss:	$(K_1 - K_2) + (C_1 - C_2)$		\$10.25
Breakeven Point:	$S^* = K_1 + (C_1 - C_2)$		\$99.75
Profit versus S*:	Profit = $C_1 - C_2$	for $S^* \leq K_1$	
	Profit = $(K_1 - S^*) + (C_2 - C_1)$	for $K_1 < S^* \leq K_2$	\$4.75
	Profit = $(K_1 - K_2) + (C_1 - C_2)$	for $S^* > K_2$	
Profit versus t*:	Profits decrease as the options expire		

(4) Effects of Varying Option Parameters: If the stock price at expiration is between the strike prices, then profits increase as K_1 and K_2 both increase and both calls become more OTM. However, this also decreases the maximum profit and increases the maximum loss. If the stock price at expiration is below the lower strike K_1, then the maximum profit increases as the strikes become farther apart. So if the stock outlook is very bearish, then decrease delta by decreasing the strike of the written call and by increasing the strike of the long call. If the stock outlook is less bearish then decrease delta by increasing the strikes of both calls. The strategy produces optimal results when the stock price at expiration is close to the strike price of the written call, K_1. This strategy is the least risky of the bearish stock--neutral volatility strategies.

As the time to expiration increases, the difference between the two call prices is almost constant, so profits are independent of t.

(5) Equivalent Positions:

Buy stock, write call with K_1 and buy put with higher strike K_2

Buy put with K_2 and write put with K_1

(6) Additional Comments: The vertical bear call spread is a strategy whose payoff is almost identical to that of shorting the underlying stock when the stock price at expiration falls somewhere between the strikes of the two options. If the stock price at expiration is below K_1 or above K_2, then profits and losses are capped. So the strategy is similar to buying a put option and paying for it with the upside profit potential.

In contrast to the bull call spread, the bear spread is established for a credit because the higher priced ITM call is written, and the lower priced OTM call is purchased.

Note from (5) that the same strategy can be implemented with put options and is then called a vertical bull put spread. In this case the maximum profit or ceiling is $(K_2 - K_1) + (P_1 - P_2)$, and the maximum loss or floor is $(P_2 - P_1)$, and the payoff characteristics of the put and call spreads are almost identical. However, since the long put is ITM it costs more than the OTM written put, so the short put spread is initiated for a debit in contrast to the short call spread.

Short Collar

(1) Description: Buy an OTM put option contract with strike price K_2 and write an ITM call option contract with a lower strike price K_1 for every 100 shares of ZYX stock owned. Both options have the same time to expiration, t.

Example:

Buy 1 ZYX Jun 110 Put contract for $1,412.50

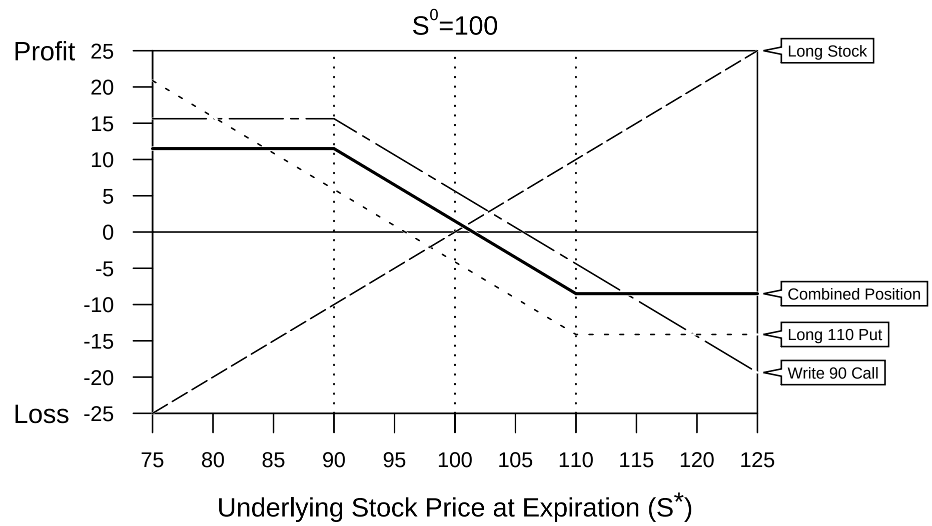
Write 1 ZYX Jun 90 Call contract for $1,562.50

We own 100 shares of ZYX stock

Current price of ZYX is $100 per share.

(2) Payoff Diagram: See Figure 49.

Figure 49. Payoff Diagram for Short Collar



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume that S^* = $95

Maximum Profit:	$(K_2 - S^0) + (C - P)$		$11.50
Maximum Loss:	$(K_1 - S^0) + (C - P)$		$8.50
Breakeven Point:	$S^* = (K_1 + K_2 - S^0) + (C - P)$		$101.50
Profit versus S*:	$\text{Profit} = (K_2 - S^0) + (C - P)$	for $S^* \leq K_1$	
	$\text{Profit} = (K_1 + K_2) - (S^* + S^0) + (C - P)$	for $K_1 < S^* \leq K_2$	$6.50
	$\text{Profit} = (K_1 - S^0) + (C - P)$	for $S^* > K_2$	
Profit versus t*:	Profits increase as the options expire		

(4) Effects of Varying Option Parameters: This strategy pays $(C - P)$ more than the short underlying stock when S^* is between the strike prices. This premium is relatively constant as long as the strikes are the same distance from the initial stock price, S^0.

As the time to expiration increases, the call price increases more than the put price so total profits increase.

(5) Equivalent Positions:

Buy call with K_2 and write call with K_1

Buy put with K_2 and write put with K_1

(6) Additional Comments: Note from (5) that this strategy is equivalent to the vertical bear call and bull put spreads discussed previously.

The short collar allows equity investors to react to short term events that can reverse the upward price movement of a stock. Without options the only possible strategy in response to such events is to sell the stock. However, the short collar allows the owner of a stock to profit from a short term price decline and then profit from longer term price increases without altering the original stock position.

e. Bearish Stock Outlook-Increasing or Long Volatility Outlook

The fifth category of options strategies that we discuss consists of those designed to produce positive returns when the price of the underlying stock decreases and when the stock volatility increases. The positions used to implement these strategies should have negative delta to insure that the position value increases as the stock price increases. The positions should also have positive vega to insure that the position value also increases as implied volatility increases. Since positive vega usually means positive gamma, the extra benefits from combining positive gamma with negative delta are obtained.

The strategies include, in order of decreasing risk:

- Long ITM Put
- Short Stock plus Long OTM Call

Long ITM Put

(1) Description: Buy a put option contract on stock ZYX with strike price K greater than the current stock price and with time to expiration, t.

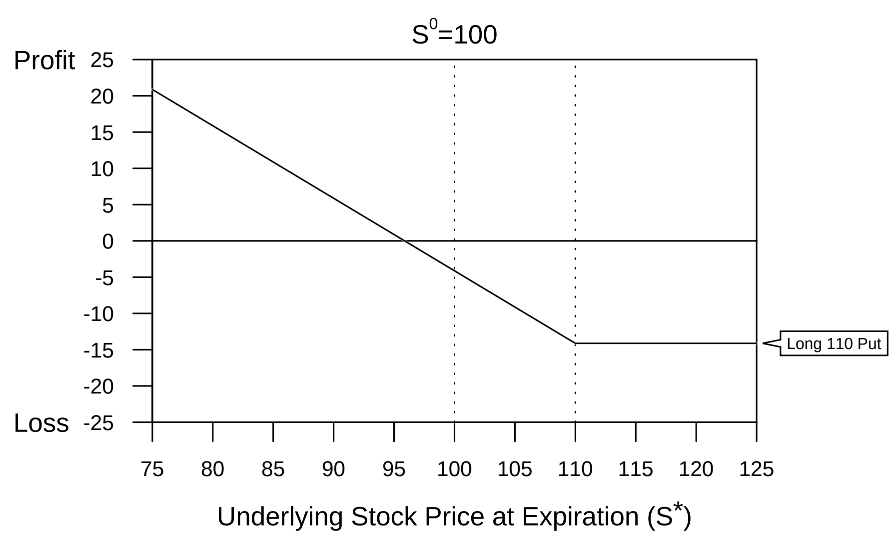
Example:

Buy 1 ZYX Jun 110 Put option contract for $1,412.50

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 50.

Figure 50. Payoff Diagram for Long ITM Put



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume that S^* = \$90

Maximum Profit:	K - P		\$95.875
Maximum Loss:	-P		\$14.125
Breakeven Point:	S* = K - P		\$95.975
Profit versus S*:	Profit = K - S* -P	for S* < K	\$5.875
	Profit = -P	for S* ≥ K	
Profit versus t*:	Profits decrease as the put option expires		

(4) Effects of Varying Option Parameters: This position is the bearish analogue to the bullish stock-long volatility strategy of buying an ITM call option. The payoff is less than that of shorting the stock by an amount equal to (S^0 - K + P), when S^* is less than K. In return, losses are limited to $-P$ if S^* increases above K. As K increases and the put becomes more ITM, the underperformance relative to the short stock decreases, but the maximum loss increases. The strategy becomes more bearish because profits increase for a fixed decrease in the stock price. The strategy also becomes riskier as the put strike increases because losses increase for a fixed increase in the stock price and delta becomes more negative. Buying a naked or uncovered put option is equivalent to shorting stock and buying an insurance policy that provides protection against an increase in the value of the underlying.

As the time to expiration increases, the put price increases and profits decrease.

(5) Equivalent Positions: Short stock and buy call.

(6) Additional Comments: The long put strategy allows a bearish investor to profit from a decrease in the stock price while limiting losses to the put premium if the stock price actually rises. As in the case of the buyer of naked calls, there are two types of buyers of naked puts. The first purchases that quantity of put options which returns \$1 for every \$1 decrease in the stock price. The second is the speculator who invests everything in puts and seeks to maximize the dollar return per \$1 decrease in the stock price.

Short Stock Plus Long OTM Call

(1) Description: Short sell ZYX stock and buy an OTM call option contract on stock ZYX with strike price K and time to expiration, t.

Example:

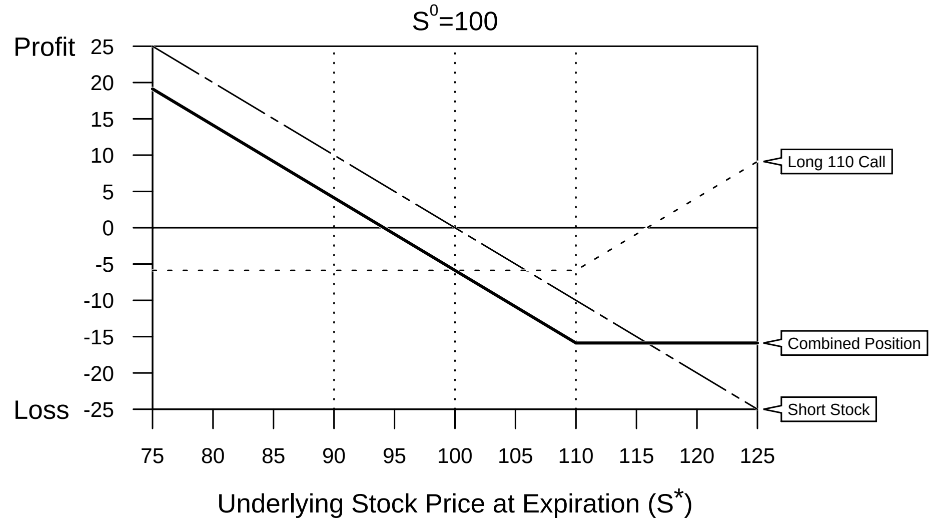
Short sell 100 shares of ZYX stock.

Buy 1 ZYX Jun 110 Call option contract for \$587.50.

Current price of ZYX stock is \$100 per share.

(2) Payoff Diagram: See Figure 51.

Figure 51. Payoff Diagram for Short Stock and Long OTM Call



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume that S^* = \$90.

Maximum Profit:	S^0 - C		\$94.125
Maximum Loss:	K - S^0 + C		\$15.875
Breakeven Point:	S* = S^0 - C		\$94.125
Profit versus S*:	Profit = S^0 - S* - C	for S* ≤ K	\$4.125
	Profit = S^0 - K - C	for S* > K	
Profit versus t*:	Profits decrease as the call option expires		

(4) Effects of Varying Option Parameters: This position is the bearish analogue to the bullish stock-long volatility strategy of buying an OTM put option with the long stock. It is also equivalent to the previous strategy of buying an uncovered put. The payoff of this strategy is less than that of shorting the stock by an amount equal to the call premium when S^* is less than K. In return, losses are limited to (S^0 - K - C) if S^* increases above K. As the strike price increases and the call becomes more OTM, the underperformance relative to the short stock decreases because the call becomes cheaper, but the maximum loss increases. The strategy becomes more bearish because profits increase for a fixed decrease in the stock price. The strategy also becomes riskier as the call strike increases because losses increase for a fixed increase in the stock price and delta decreases. The overall risk of the strategy is equivalent to that of the long ITM put.

As the time to expiration increases, the call price increases and profits decrease.

(5) Equivalent Positions: Buy put

(6) Additional Comments: From (5) we see that this strategy is the same as buying a naked or uncovered put option. In this case the call is an insurance policy against the short stock position. The cost of this strategy is the cost of

shorting ZYX which is 50% of the stock price or $50, plus the cost of buying the call which is $5.875 for a total of $55.875. The cost of buying an ITM put is $14.125. So buying the put can be established for a quarter of the cost of the equivalent strategy, and the investor is not subject to the potential problems of shorting stock. Therefore, buying the put is preferred unless it is unavailable at the proper strike or overpriced, or the call is underpriced, or we want to reduce the risk of an existing short stock position.

f. Bearish Stock Outlook-Decreasing or Short Volatility Outlook

The sixth category of options strategies that we discuss consists of those designed to produce positive returns when the price of the underlying stock decreases and when the stock volatility also decreases. The positions used to implement these strategies should have negative delta to insure that the position value increases as the stock price decreases. The positions should also have negative vega to insure that the position value also increases as the implied volatility decreases. However, negative vega usually means negative gamma which reduces the profits of negative delta strategies.

The strategies include, in order of decreasing risk:

- Write ITM Call
- Short Stock plus Write OTM Put

Write ITM Call

(1) Description: Write a call option on stock ZYX with strike price *K* less than the current stock price and with time to expiration, *t*.

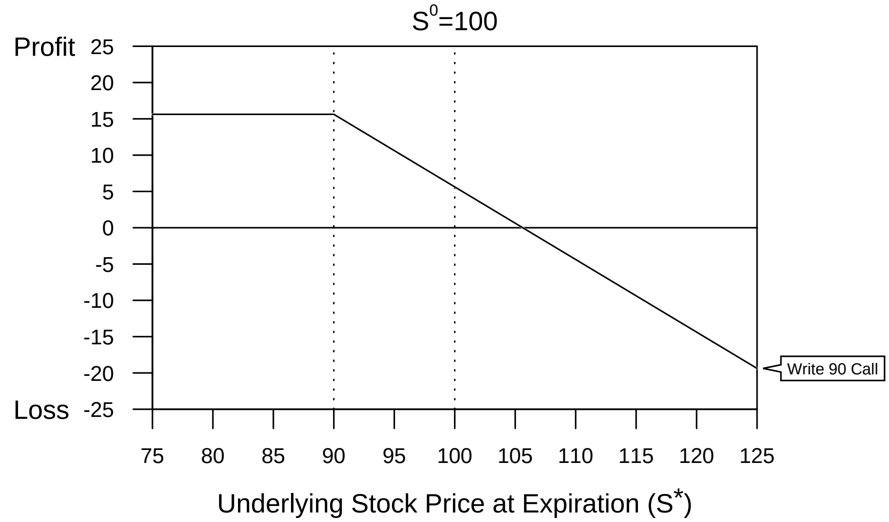
Example:

Write 1 ZYX Jun 90 Call contract for $1,562.50

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 52.

Figure 52. Payoff Diagram for Written ITM Call



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = $90

Maximum Profit:	C		$15.625
Maximum Loss:	Unlimited		
Breakeven Point:	S* = K + C		$105.625
Profit versus S*:	Profit = (K - S*) + C	for S* > K	$15.625
	Profit = C	for S* ≤ K	
Profit versus t*:	Profits increase as the call option expires		

(4) Effects of Varying Option Parameters: This position is the bearish analogue to the bullish stock-short volatility strategy of writing an ITM put option. The payoff exceeds that of shorting the underlying stock by an amount ($K - S^0 + C$) when S^* is greater than K. The cost of this extra payoff is a limited upside profit of C if S^* is less than K. As K decreases and the call becomes more ITM, the additional payoff decreases but the maximum payoff increases. The strategy becomes more bearish because obtaining higher profits requires a larger decrease in the stock price. The strategy also becomes riskier as the call strike decreases because losses are greater for a given increase in the stock price and delta becomes more negative. Writing a call option is equivalent to selling a share of stock with an insurance policy.

As the time to expiration increases, the call option price increases and profits increase.

(5) Equivalent Positions: Short stock and write put

(6) Additional Comments: Call writing is a bearish-neutral strategy which should be implemented with caution. If the stock price decrease is too large and the call is not far enough ITM, then the writer incurs an opportunity cost because profits are less than those of an equivalent short stock position. If the stock price increases, the writer's loss is mitigated only by the call

premium. The strategy produces optimal results when S^* is equal to or slightly less than the strike price. So the call writer should select a strike that is close to the price at which the stock is expected to finish. If the outlook is accurate the position will gain higher profits than the equivalent short stock position.

This strategy is slightly less risky than the short stock strategy because losses are always less for any stock price increase. However, the ITM call writer is also subject to early assignment if the stock pays a dividend and goes ex during the lifetime of the option.

Short Stock Plus Write OTM Put

(1) Description: Write a put option contract on stock ZYX with strike price K less than the current stock price and with time to expiration, t. Simultaneously short 100 shares of ZYX.

Example:

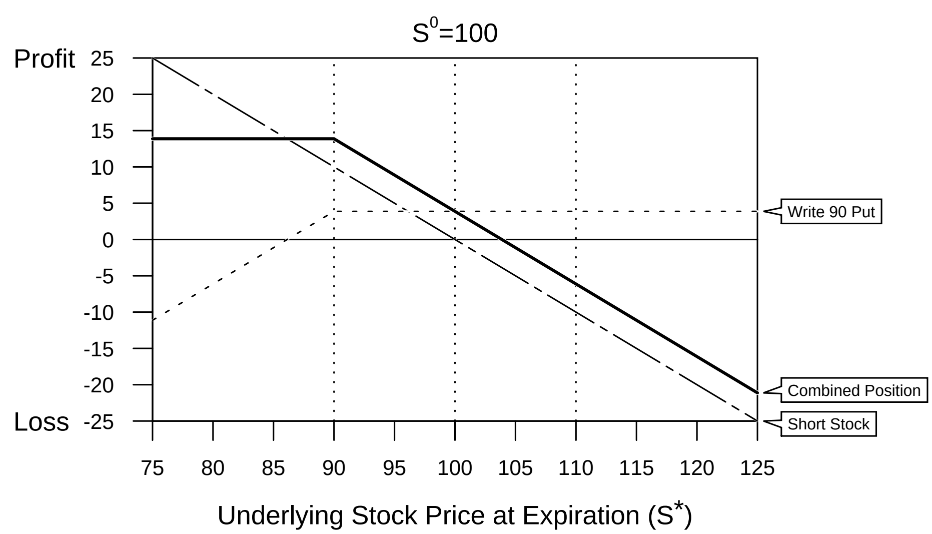
Write 1 ZYX Jun 90 Put contract for $387.50

Short sell 100 shares of ZYX stock.

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 53.

Figure 53. Payoff Diagram for Short Stock and Written OTM Put



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = \$90.

Maximum Profit:	S^0 - K + P		\$13.875
Maximum Loss:	Unlimited		
Breakeven Point:	$S^* = S^0 + P$		\$103.875
Profit versus S*:	Profit = S^0 - K + P	for $S^* < K$	
	Profit = $S^0 - S^* + P$	for $S^* \geq K$	\$13.875
Profit versus t*:	Profits increase as the put option expires		

(4) Effects of Varying Option Parameters: This position is the bearish analogue to the bullish stock-short volatility strategy of writing an OTM call option against the long stock. It is also equivalent to the previous strategy of writing an uncovered or naked call. The payoff exceeds that of shorting the underlying stock by an amount equal to the put premium when S^* is greater than K. However, the cost of this extra payoff is a limited upside profit of (S^0 - K + P) when S^* is less than K. As the strike decreases and the put becomes more OTM, the additional payoff decreases but the maximum payoff increases. The strategy becomes more bearish because obtaining higher profits requires a larger decrease in the stock price. The strategy also becomes riskier as the put strike decreases because losses become greater for a given increase in the stock price and delta becomes more negative.

As the time to expiration increases, the put price increases and profits increase.

(5) Equivalent Positions: Write call.

(6) Additional Comments: From (5) we see that this strategy is the same as writing a naked or uncovered call option and is bearish-neutral and should be implemented with caution. If the stock price finishes lower than (K - P) then the investor incurs an opportunity cost because profits are less than for an outright short stock position. However, if the stock price increases, the losses are always reduced by the price of the put.

The cost of initiating this strategy is the cost of shorting ZYX which is 50% of the stock price or \$50, plus the cost of writing the put which is 20% of the stock price less the amount that the put is OTM, or \$10, for a total of \$60. The cost of writing the ITM call is 20% of the stock price or \$20. So writing the call can be established for a third of the cost of the equivalent strategy, and the investor is not subject to the potential problems of shorting stock. Therefore, writing the call is preferred unless it is unavailable at the proper strike or underpriced, or the put is overpriced, or we want to reduce the risk of an existing short stock position.

g. Neutral Stock Outlook-Increasing or Long Volatility Outlook

The seventh category of options strategies that we consider consists of those designed to produce positive returns when the investor has no opinion or is completely uncertain about the future direction of the underlying stock price, and when the volatility increases. The positions used to implement these strategies should be delta neutral to insure that the position value is not affected by changes in the stock price. The positions should also have positive vega to insure that the position value increases as the implied volatility increases. Since positive vega usually means positive gamma, then the delta neutral strategies will also profit if the stock price undergoes a large unexpected move in either direction.

It is important to note that since the strategies in this category are designed to profit from an increase in the implied volatility, then the payoff diagrams may not accurately depict the true profit and loss situation. The standard option payoff diagram shows profits only as a function of the underlying stock price and not as a function of the volatility. Furthermore, the diagrams depict the gains and losses only at expiration. However, long volatility positions are seldom held to expiration because the gains from a volatility increase are completely consumed by time decay. Therefore, the standard diagrams show only the profits and losses due to stock price moves in combination with positive gamma. So the diagrams only apply if the increase in implied volatility is a result of a change in realized volatility that causes a large move in the stock price and if the position is held until expiration.

The strategies include, in order of decreasing risk:

- Long Straddle
- Long Strangle
- Short Butterfly
- Short Condor
- Short ATM Horizontal Spread
- Ratio Call Backspread
- Ratio Put Backspread

Long Straddle

The straddle belongs to the general category of options strategies known as combinations. A combination involves taking either an all long or an all short position in both the calls and the puts of the same underlying stock. The options can have different strike prices and maturity dates. The long straddle combination consists of a long call and a long put on the same underlying stock. Both options have the same strike price and the same time to expiration.

(1) Description: Buy a call option and a put option on stock ZYX, each with the same strike price and time to expiration.

Example:

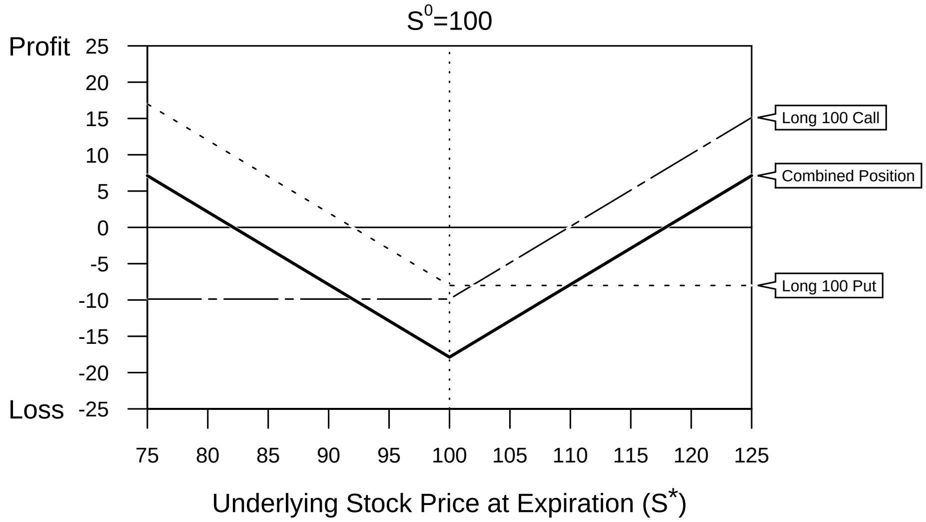
Buy 1 ZYX Jun 100 Call contract for $987.50

Buy 1 ZYX Jun 100 Put contract for $800.00

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 54.

Figure 54. Payoff Diagram for the Long Straddle



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume $S^* = \$80$

Maximum Profit:	Unlimited on upside		
Maximum Loss:	(C + P)		$17.875
Breakeven Points:	S* = K ± (C + P)		$82.125 and $117.875
Profit versus S*:	Profit = (K - S*) - (C + P)	for S* ≤ K	$2.125
	Profit = (S* - K) - (C + P)	for S* > K	
Profit versus t*:	Profits decrease as both options expire		

(4) Effects of Varying Option Parameters: The goals of any neutral stock-long volatility strategy are to minimize the size of the stock price move required for a profit, and to realize the largest possible profit for a given stock price move. The first goal is met by minimizing the distance between the breakeven points. In a long straddle this distance is given by $2(C + P)$, or twice the sum of the option prices. The distance is a minimum when both options are ATM and decreases with the time to expiration. In a long straddle the second goal can only be met by increasing the slope of the profit line outside the breakeven points. This can only be accomplished by buying more than one put-call combination. However, this also proportionally increases potential losses if the anticipated stock price move does not occur. If the stock outlook is neutral to slightly bullish and a large price increase is considered more likely than a decrease, then lowering the strike price increases delta and increases the profits of a given price rise. Finally, note that the maximum loss is incurred when the stock price at expiration equals the strike price of the options.

When the options are ATM, delta is slightly positive (about 0.16 for the position represented by the example). Delta can be reduced to zero by increasing the strike price about 5% which does not significantly change vega and gamma. However, vega and gamma decrease if the strike price decreases.

(5) Equivalent Positions:

Long stock plus buy 2 puts

Short stock plus buy 2 calls

(6) Additional Comments: Since the long straddle involves buying 2 options which are nearly ATM, time decay causes a significant erosion of profits as the options expire. As is usually the case, a position with large positive vega and gamma also has a large negative theta. In the example, if the stock price at expiration is $80, then profits are $2.125. However, if the stock price declines to $80 after 30 days when the options are still 120 days from expiration, then profits are $4.00. So the strategy is most profitable when the straddle is purchased immediately before the anticipated realized volatility and price move and sold immediately after. Also, in the above example the stock price must increase or decrease by 18% for the strategy to profit.

Long Strangle

(1) Description: Buy a put option on stock ZYX with strike price K_1 less than the current stock price and buy a call option on stock ZYX with a higher strike price K_2. Both options have the same time to expiration.

Example:

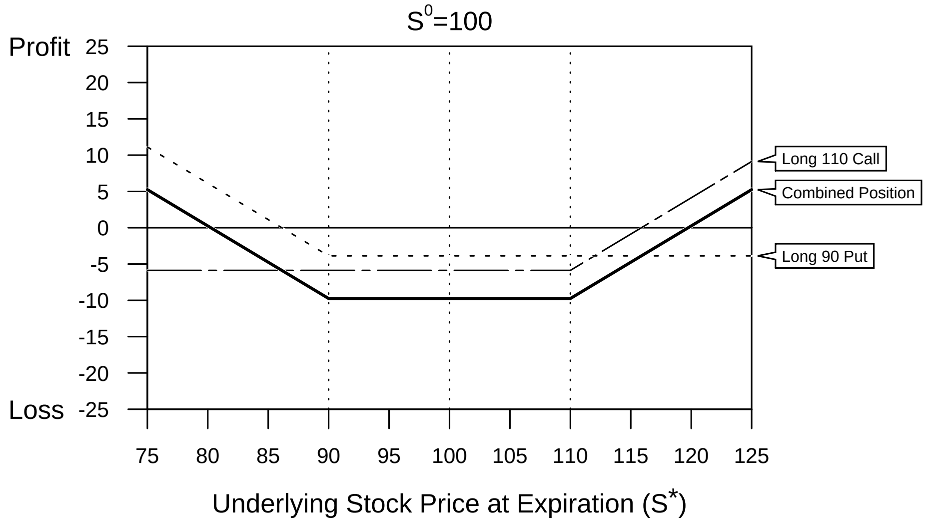
Buy 1 ZYX Jun 90 Put contract for $387.50

Buy 1 ZYX Jun 110 Call contract for $587.50

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 55.

Figure 55. Payoff Diagram for the Long Strangle



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = $80.

Maximum Profit:	Unlimited on upside		
Maximum Loss:	(C + P)		$9.75
Breakeven Points:	$S^* = K_1 - (C + P)$ and $S^* = K_2 + (C + P)$		$80.25 and $119.75
Profit versus S*:	Profit = $(K_1 - S^*) - (C + P)$	for $S^* \leq K_1$	$0.25
	Profit = $-(C + P)$	for $K1 < S^* < K_2$	
	Profit = $(S^* - K_2) - (C + P)$	for $S^* \geq K_2$	
Profit versus t*:	Profits decrease as the options expire		

(4) Effects of Varying Option Parameters: The distance between the breakeven points is given by $(K_2 - K_1) + 2(C + P)$ and decreases as the strikes move closer together and as the time to expiration decreases. The slopes of the profit lines outside the breakeven points equal 1 and can only be increased by purchasing more put-call combinations. Increasing or decreasing both strikes an equal amount decreases or increases delta, shifts the entire payoff curve right or left, and makes the strategies slightly bearish or bullish, respectively. Increasing both strikes to make the strategy delta neutral also slightly increases vega and gamma.

(5) Equivalent Positions:

Long stock plus buy put with K_1 plus buy put with K_2

Short stock plus buy call with K_1 plus buy call with K_2

Buy call with K_1 plus buy put with K_2

(6) Additional Comments: The strangle described above uses OTM options, but the ITM version has exactly the same profit and loss characteristics. The OTM version is preferred because it is much cheaper. The OTM 110 Call - 90 Put strangle in the example costs $9.75 compared

with $29.75 for the corresponding ITM 90 Call - 110 Put strangle. Note also that the OTM strangle is half the price of the corresponding ATM straddle.

Short Butterfly Call or Put Spread

(1) Description: Write a call option with a given strike price K_1, write a second call option with a higher strike price K_3, and buy 2 call options with a strike price K_2 that is midway between the other two. All four call options have the same time to expiration, and the strike price of the purchased options is usually close to the current stock price. The position is referred to as a short K_1-K_2-K_3 call butterfly.

Example:

A short 90-100-110 Call Butterfly:

Write 1 ZYX Jun 90 Call contract for $1,562.50

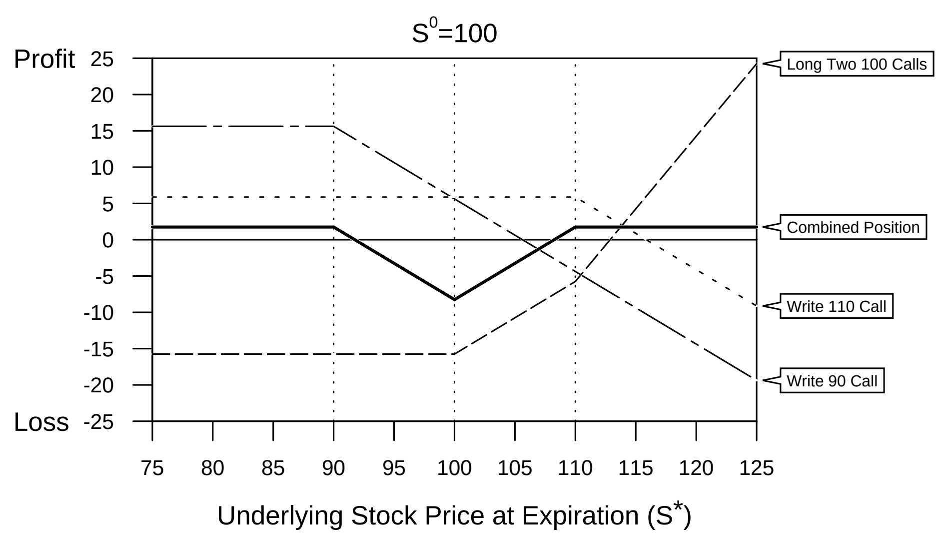
Write 1 ZYX Jun 110 Call contract for $587.50

Buy 2 ZYX Jun 100 Call contracts for $1,975.00

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 56.

Figure 56. Payoff Diagram for the Short Butterfly Call Spread



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = \$105.

Maximum Profit:	$(2C_2 - C_1 - C_3)$		\$1.75
Maximum Loss:	$(K_2 - K_1) - (2C_2 - C_1 - C_3)$		\$8.25
Breakeven Points:	$S^* = K_1 + (2C_2 - C_1 - C_3)$ and		\$91.75 and \$108.25
	$S^* = (2K_2 - K_1) - (2C_2 - C_1 - C_3)$		
Profit versus S*:	Profit = $(2C_2 - C_1 - C_3)$	for $S^* \leq K_1$	
	Profit = $(2C_2 - C_1 - C_3) - (S^* - K_1)$	for $K_1 < S^* \leq K_2$	
	Profit = $(2C_2 - C_1 - C_3) - (2K_2 - K_1 - S^*)$	for $K_2 < S^* \leq K_3$	-\$3.25
	Profit = $(2C_2 - C_1 - C_3) - (2K_2 - K_1 - K_3)$	for $S^* > K_3$	
Profit versus t*:	Profits decrease as the options expire		

(4) Effects of Varying Option Parameters: The short butterfly spread is a lower risk and return alternative to the long straddle. For the ZYX example, the maximum payoff is only \$1.75 versus an unlimited payout for the K = 100 straddle. However, the maximum loss is \$8.25 compared with \$17.875 for the straddle. Also, the short butterfly profits from only an 8% move in the underlying compared with 18% for the long straddle. The position represented by the example is delta neutral but vega and gamma are only about 10% as large as the vega and gamma of the straddle or strangle.

As the time to expiration increases, the prices of the long options increase slightly more than the prices of the written options, so profits decrease by a small amount.

(5) Equivalent Positions: There are 11 possible equivalent positions for this strategy. We list only the three that consist entirely of options. Let C(K) and P(K) denote a call and put with strike price K. A minus sign denotes a written option. Then the equivalent positions are:

-P(90) +P(100) + C(100) - C(110)

-C(90) +P(100) + C(100) - P(110)

-P(90) + 2P(100) - P(110)

Since so many different options can be used to implement the strategy, then the likelihood of finding mispriced options and increasing profits is that much greater.

(6) Additional Comments: Note from the last equivalent position above that the same strategy can be implemented with put options and is then called a short butterfly put spread because it is also established for a credit. The payoff characteristics are almost identical to that of the call spread. The short K_1-K_2-K_3 butterfly is also the sum of two individual spreads. The short K_1 call-long K_2 call is a vertical bear call spread, and the long K_2 call-short K_3 call is a vertical bull call spread.

The short butterfly strategy can be made bullish or bearish by increasing or decreasing delta. Delta increases and the strategy becomes bullish when the call strikes decrease or the put strikes increase. Delta decreases and the strategy becomes bearish if the call strikes increase and the put strikes decrease.

Short Condor Call or Put Spread

(1) Description: Write a call option with a given strike price K_1, and write a second call option with a higher strike price K_4. Buy two call options with strike prices K_2 and K_3 that are between K_1 and K_4, and such that K_3 is higher than K_2. The distance between K_1 and K_2 equals the distance between K_3 and K_4, and the price of the underlying usually lies between the strikes of the written options. The position is referred to as a short K_1-K_2-K_3-K_4 call condor and is the butterfly with the middle strike split.

Example:

A short 90-95-105-110 Call Condor:

Write 1 ZYX Jun 90 Call contract for $1562.50

Write 1 ZYX Jun 110 Call contract for $587.50

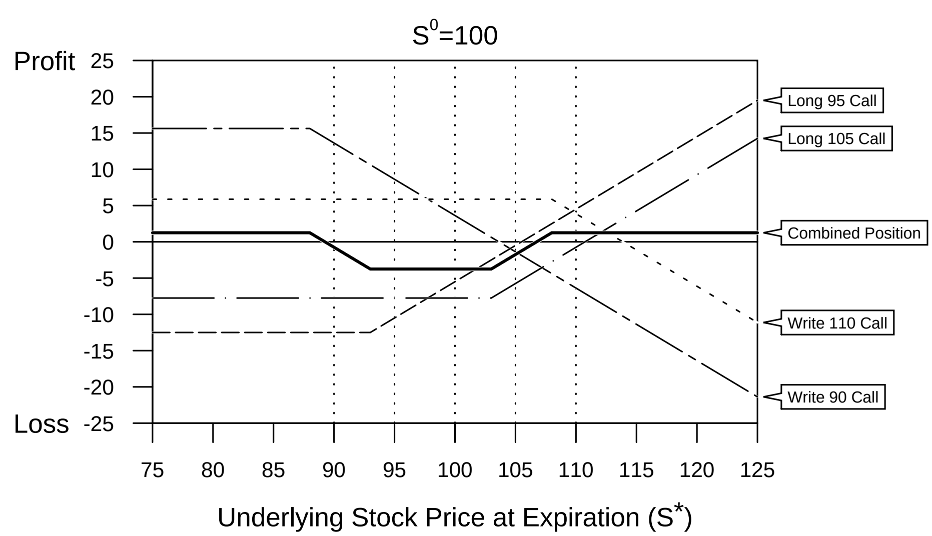
Buy 1 ZYX Jun 95 Call contract for $1250.00

Buy 1 ZYX Jun 105 Call contract for $775.00

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 57.

Figure 57. Payoff Diagram for the Short Condor Call Spread



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume that S^* = \$105.

Maximum Profit:	$(C_1 + C_4 - C_2 - C_3)$		\$1.25
Maximum Loss:	$(K_2 - K_1) - (C_1 + C_4 - C_2 - C_3)$		\$3.75
Breakeven Points:	$S^* = K_1 + (C_1 + C_4 - C_2 - C_3)$ and		\$91.25 and \$108.75
	$S^* = (K_3 + K_2 - K_1) - (C_1 + C_4 - C_2 - C_3)$		
Profit versus S*:	Profit = $(C_1 + C_4 - C_2 - C_3)$	for $S^* \leq K_1$	
	Profit = $(K_1 + S^*) + (C_1 + C_4 - C_2 - C_3)$	for $K_1 < S^* \leq K_2$	
	Profit = $(C_1 + C_4 - C_2 - C_3) - (K_2 - K_1)$	for $K_2 < S^* \leq K_3$	-\$3.75
	Profit = $(S^* - K_3) + (K_1 - K_2) +$ $(C_1 + C_4 - C_2 - C_3)$	for $K_3 < S^* \leq K_4$	
	Profit = $(K_1 - K_2) + (K_4 - K_3) +$ $(C_1 + C_4 - C_2 - C_3)$	for $S^* > K_4$	
Profit versus t*:	Profits decrease as the options expire		

(4) Effects of Varying Option Parameters: The short condor spread is a lower risk and return alternative to the long strangle. For the ZYX example, the maximum payoff is only \$1.25 versus an unlimited payout for the 90-110 OTM strangle. However, the maximum loss is \$3.75 compared with \$9.75 for the strangle. Also, the short condor profits from only an 8% move in the underlying compared with 20% for the long strangle. The position represented by the example is delta neutral , but like the butterfly, vega and gamma are only about 10% as large as vega and gamma of a straddle or strangle.

As the time to expiration increases, the prices of the long options increase slightly more than the prices of the written options, so profits decrease a small amount.

(5) Equivalent Positions: There are 15 possible equivalent positions for this strategy, but we list only the five that consist entirely of options. As before let C(*K*) and P(*K*) denote a call and put with strike price *K*. A minus sign denotes a written option. Then the equivalent positions are:

-P(90) + P(95) + C(105) - C110)

-P(90) + C(95) + P(105) - C(110)

-C(90) + P(95) + C(105) - P(110)

-C(90) + C(95) + P(105) - P(110)

-P(90) + P(95) + P(105) - P(110)

Since so many different options can be used to implement the strategy, then the likelihood of finding mispriced options and increasing profits is that much greater.

(6) Additional Comments: The short condor call spread also has an equivalent that uses all puts, and can be viewed as the combination of a vertical bull and a vertical bear spread.

Short Horizontal Call or Put Spread

(1) Description: Write a call option with a given strike price *K* and time to expiration t_2, and buy a second call option with the same strike price but a shorter time to expiration t_1.

Example:

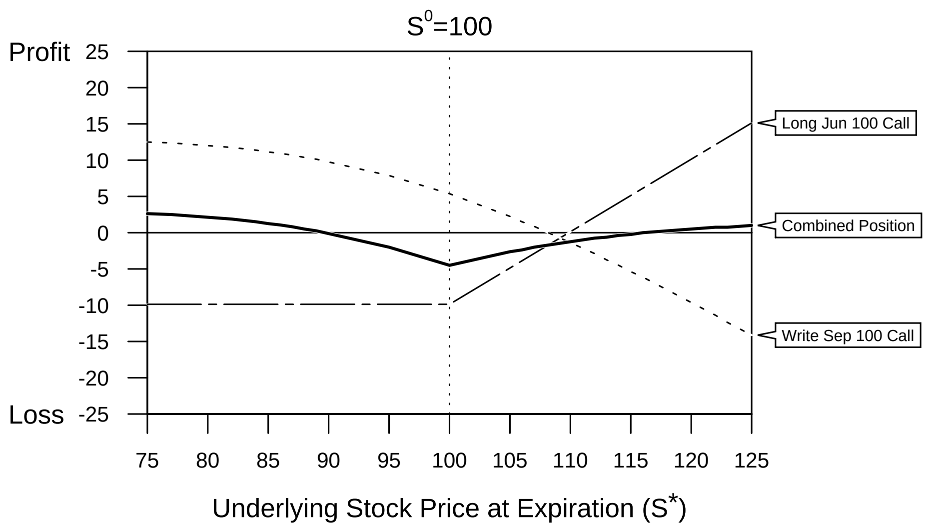
Write 1 ZYX Sep 100 Call contract for $1,287.50

Buy 1 ZYX Jun 100 Call contract for $987.50

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 58. Note that since the two options have different maturity dates, the payoff diagram cannot be depicted like the previous ones. The profit and loss is as of the day that the June call expires and assumes that the longer term call is sold at that time. The payoff of the September call then depends not only upon *S** and *K*, but also upon the volatility of ZYX, the riskless interest rate, and the number of days remaining to expiration. Note also that the equations in the Profit and Loss Analysis table are omitted in places because one of the options has not expired so the equations are also functions of volatility, interest rate, and time to expiration.

Figure 58. Payoff Diagram for the Short Horizontal Call Spread



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = $105

Maximum Profit:	$(C_2 - C_1)$ on downside; less on upside	$3.00 and $1.625
Maximum Loss:		$4.50
Breakeven Point:		$89.875 and $116
Profit versus S*:		-$2.625
Profit versus t*:	Profits decrease as the options expire	

(4) Effects of Varying Option Parameters: As the strike price decreases and the calls become more ITM, the point of maximum loss shifts to lower stock prices and the strategy becomes neutral-bullish because the stock price must increase slightly for the spread to yield the maximum profit. Similarly the strategy becomes neutral-bearish as the strike increases. For fixed t_2 the maximum profit increases and the maximum loss decreases as t_1, the shorter expiration time of the written option decreases. Note that since the long option has a shorter lifetime than the written option, it has a smaller vega and a larger gamma. Therefore, this strategy actually has a negative vega and a positive gamma, in contrast to all of the other strategies that we have discussed. So the short horizontal spread profits when short term implied volatility increases and long term implied volatility decreases.

(5) Equivalent Positions:

Long stock plus buy put with t_1 plus write call with t_2

Buy put with t_1 and write put with t_2

6) Additional Comments: The payoff of this strategy resembles that of the short butterfly spread. Note from (5) above that the same strategy can be implemented with a long put with time to expiration t_1 and a written put with a longer expiration date t_2. The short horizontal put spread often has less desirable risk and return characteristics than the call version. For example, the ZYX Jun-Sep 100 put spread has the same maximum loss as the call spread, but the maximum profit is only $1.875 compared with $3.00 for the call spread.

The short horizontal put spread becomes slightly bullish as the put strikes decrease and becomes slightly bearish as the put strikes increase.

Ratio Call Backspread

(1) Description: Write a call option with strike price K_1 and buy two call options with a higher strike price, K_2. All three options have the same time to expiration, t.

Example:

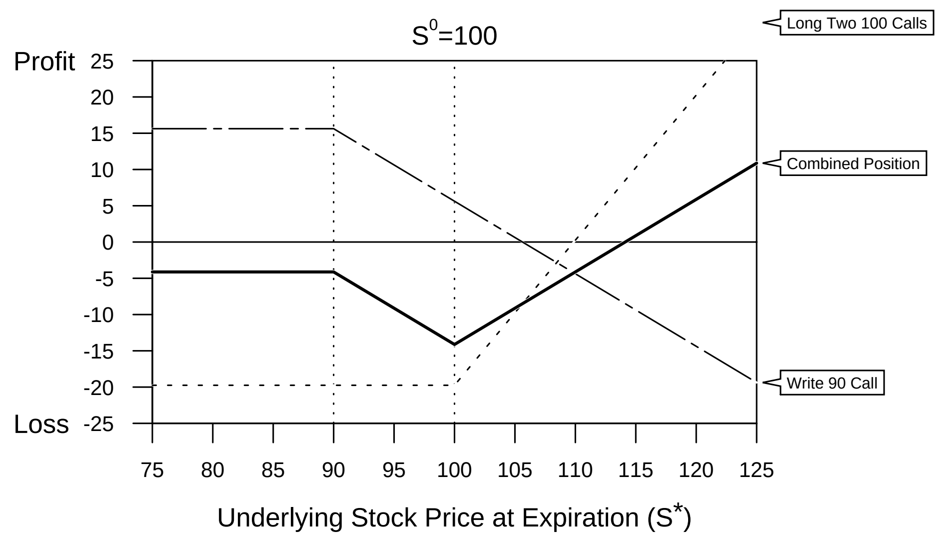
Write 1 ZYX Jun 90 Call contract for $1,562.50

Buy 2 ZYX Jun 100 Call contracts for $1,975.00

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 59.

Figure 59. Payoff Diagram for the Ratio Call Backspread



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = $105

Maximum Profit:	Unlimited		
Maximum Loss:	$(K_2 - K_1) + (2C_2 - C_1)$		$4.50
Breakeven Point:	$S^* = (2C_2 - C_1) + (2K_2 - K_1)$		$114.125
Profit versus S*:	Profit = $(C_1 - 2C_2)$	for $S^* \leq K_1$	
	Profit = $(C_1 - 2C_2) - (S^* - K_1)$	for $K_1 < S^* \leq K_2$	
	Profit = $(C_1 - 2C_2) + (S^* + K_1 - 2K_2)$	for $S^* > K_2$	-$9.125
Profit versus t*:	Profits decrase as the options expire		

(4) Effects of Varying Option Parameters: Since this is a delta neutral strategy, the long calls must have lower delta than the written call, so they must have a higher strike price. As the difference between the strikes increases, the maximum loss increases, as does the magnitude of the price move required for a profit, so the strategy becomes riskier. The value of the written side of the position should be greater than the value of the long side so that a profit results from a price move in either direction. The point of maximum loss occurs at the higher strike price, and the profit or loss limit on the downside occurs at the lower strike price.

(5) Equivalent Positions: Buy a call and put with K_2 and write a put with K_1

(6) Additional Comments: The ratio call backspread is a neutral stock outlook strategy, but the payoff is asymmetric. A stock price increase is more profitable than a price decrease, so the strategy actually satisfies a neutral—bullish stock outlook.

The position represented by the example actually has a large positive delta of about 0.4. The position can be made delta neutral by increasing the strike price of the long options and decreasing the strike price of the written option which also increases vega and gamma.

Ratio Put Backspread

(1) Description: Buy 2 puts with strike price K_1 and write a third put with a greater strike price, K_2. All three puts have the same time to expiration, *t*.

Example:

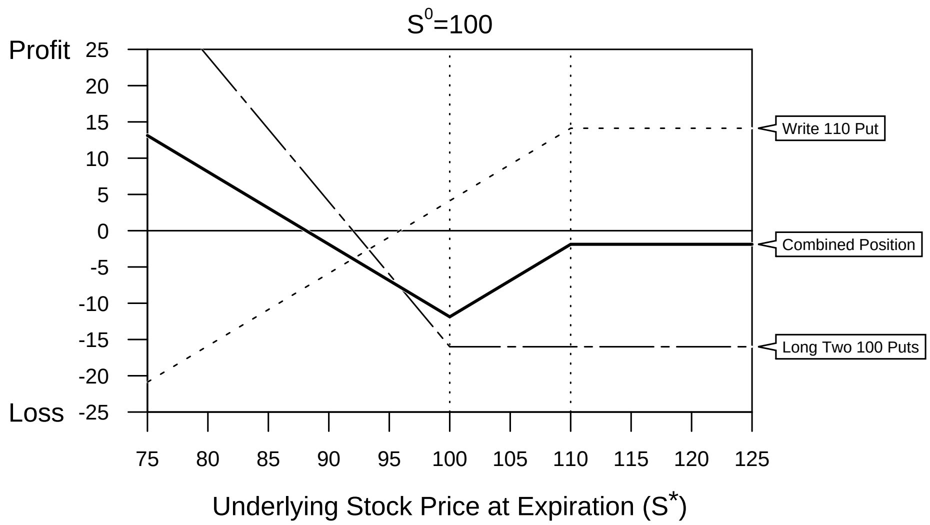
Write 1 ZYX Jun 110 Put contract for $1,412.50

Buy 2 ZYX Jun 100 Put contracts for $1,600.00

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 60.

Figure 60. Payoff Diagram for the Ratio Put Backspread



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = $105

Maximum Profit:	$(2K_1 - K_2) - (2P_1 - P_2)$		$88.125
Maximum Loss:	$(K_1 - K_2) - (2P_1 - P_2)$		$11.875
Breakeven Point:	$(2K_1 - K_2) - (2P_1 - P_2)$		$88.125
Profit versus S*:	Profit = $(2K_1 - K_2) - (2P_1 - P_2) - S^*$	for $S^* \leq K_1$	
	Profit = $(S^* - K_2) - (2P_1 - P_2)$	for $K_1 < S^* \leq K_2$	-$6.875
	Profit = $-(2P_1 - P_2)$	for $S^* > K_2$	
Profit versus t*:	Profits decrease as the options expire		

(4) Effects of Varying Option Parameters: Since this is a delta neutral strategy, the long puts must have lower delta than the written put, so they must have a lower strike price. As the difference between the strikes increases, the maximum loss increases, as does the magnitude of the price move required for a profit, so the strategy becomes riskier. The value of the written side of the position should be greater than the value of the long side so that a profit results from a price move in either direction. The point of maximum loss occurs at the lower strike price, and the profit or loss limit on the upside occurs at the higher strike price.

(5) Equivalent Positions: Buy a call and a put with K_2, write a call with K_1

(6) Additional Comments: The ratio put backspread is a neutral stock outlook strategy, but the payoff is asymmetric. A stock price decrease is more profitable than a price increase, so the strategy actually satisfies a neutral—bearish stock outlook.

The position represented by the example actually has a negative delta of about -0.25. The position can be made delta neutral by decreasing the strike price of the long options or increasing the strike price of the written option.

h. Neutral Stock Outlook-Decreasing or Short Volatility Outlook

The eighth and final category of options strategies that we consider consists of those designed to produce positive returns when the investor has no opinion or is completely uncertain about the future direction of the underlying stock price, and when the volatility decreases. The positions used to implement these strategies should be delta neutral to insure that the position value is not affected by changes in the stock price. The positions should also have negative vega to insure that the position value increases as the implied volatility decreases. However, since negative vega usually means negative gamma, then these delta neutral strategies will incur losses if the stock price undergoes a large move in either direction.

The comments regarding how the payoff diagrams do not accurately depict the true profit and loss characteristics of the strategies in the previous category apply equally to the strategies in this category. The diagrams only apply in the present case if the decrease in implied volatility causes the stock to trade within a narrow price range, and if the positions are held until expiration.

Also, if the investor's volatility outlook is incorrect and the implied volatility actually increases, then the positions incur losses because of the negative vega. If the increase in implied volatility also results in a large price move, then the position incurs additional losses because of the negative gamma. However, the losses due to both of these effects are partially offset by the passage of time because of the positive theta.

The strategies include, in order of decreasing risk:

- Short Straddle
- Short Strangle
- Write OTM Call
- Write OTM Put
- Long Butterfly

- Long Condor
- Long ATM Horizontal Spread
- Ratio Call Spread
- Ratio Put Spread

Short Straddle

(1) Description: Write a call option and a put option on stock ZYX, each with the same strike price and time to expiration.

Example:

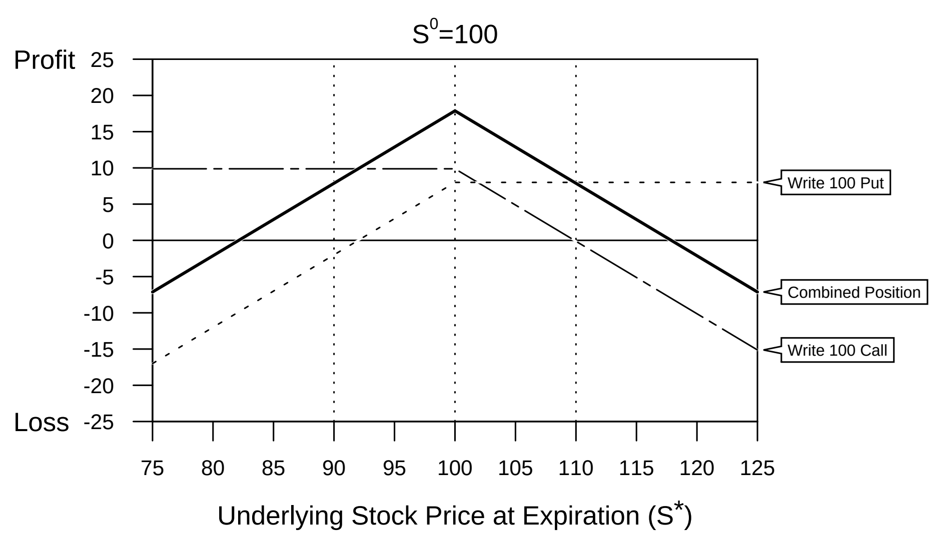
Write 1 ZYX Jun 100 Call contract for $987.50

Write 1 ZYX Jun 100 Put contract for $800.00

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 61.

Figure 61. Payoff Diagram for Short Straddle



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = $95

Maximum Profit:	(C + P)		$17.875
Maximum Loss:	Unlimited on upside		
Breakeven Points:	S* = K ± (C + P)		82.125 and $117.875
Profit versus S*:	Profit = (C + P) + (S* - K)	for S* ≤ K	
	Profit = (C + P) - (S* - K)	for S* > K	$12.875
Profit versus t*:	Profits increase as both options expire		

(4) Effects of Varying Option Parameters: The payoff of the short straddle is a maximum when the stock price at expiration equals the strike price of the two options. The strategy can be made neutral-bullish by increasing the

strike price and neutral-bearish by decreasing the strike price. In the first case, profits increase if the stock price rises, and in the second case profits decrease if the stock price falls. So the options should be struck at the value that the stock price is expected to finish. When the options are ATM, delta is slightly negative (about -0.16 for the position represented by the example). Delta can be increased to zero by increasing the strike price by about 5% which does not significantly change vega and gamma.

As the time to expiration increases, the prices of both options increase and profits increase.

(5) Equivalent Positions:

Long stock plus write two calls

Short stock plus write two puts

(6) Additional Comments: The short straddle is the riskiest of the neutral stock-short volatility strategies because it has a high negative gamma so that substantial losses are possible if the stock price undergoes a large move in either direction. Since the strategy involves writing two options that are nearly ATM, the decay of the time value of both options greatly increases the value of the position, especially near expiration. The initial margin of a short straddle equals the margin for either option, whichever is larger, plus the value of the other option. For the given example, the margin for the call is larger and equals the call value plus 20% of the price of the underlying or $29.875. The value of the put is $8.00 so the total initial margin requirement is $37.875. However, since the proceeds of the sale of both options can be applied to the margin, the net cost of establishing the short straddle is $20. Finally, note that if the options are ATM then the strategy is profitable at expiration as long as the stock price does not increase or decrease by more than $(C + P)$. For the given example, the strategy is profitable if the stock price moves less than 18% in either direction.

Short Strangle

(1) Description: Write a put option on stock ZYX with strike price K_1 and write a call option on stock ZYX with a higher strike price K_2. Both options have the same time to expiration.

Example:

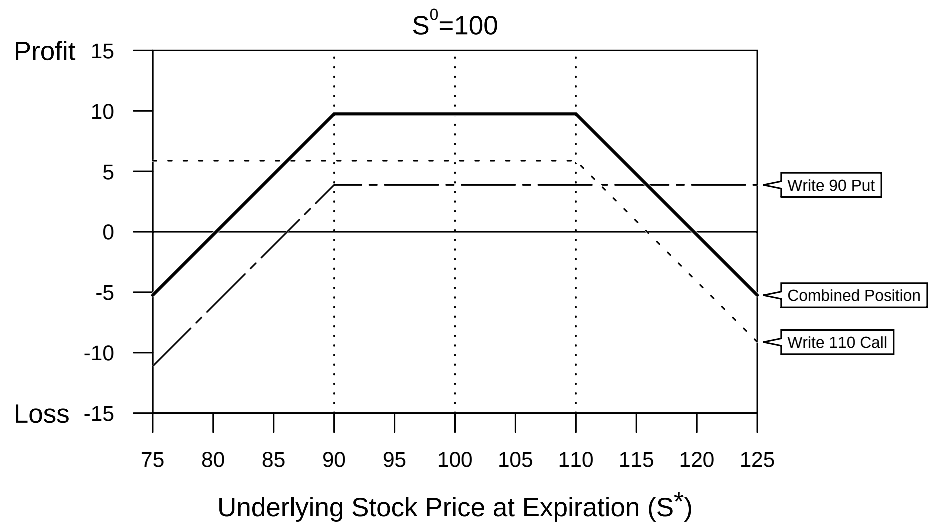
Write 1 ZYX Jun 90 Put contract for $387.50

Write 1 ZYX Jun 110 Call contract for $587.50

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 62.

Figure 62. Payoff Diagram for Short Strangle



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = \$95.

Maximum Profit:	(C + P)		\$9.75
Maximum Loss:	Unlimited on upside		
Breakeven Points:	$S^* = K_1 - (C + P)$ and $S^* = K_2 + (C + P)$		\$80.25 and \$119.75
Profit versus S*:	Profit = $(C + P) - (K_1 - S^*)$	for $S^* \leq K_1$	
	Profit = $(C + P)$	for $K_1 < S^* < K_2$	\$9.75
	Profit = $(C + P) - (S^* - K_2)$	for $S^* \geq K_2$	
Profit versus t*:	Profits increase as the options expire		

(4) Effects of Varying Option Parameters: If both strike prices are increased by the same amount, the maximum profit region shifts to higher values of S^* and the strategy becomes neutral-bullish because profits increase for a fixed increase in the stock price. If both strikes are decreased by the same amount, the strategy becomes neutral-bearish. If the distance between the strikes is increased, the profitable region widens, the maximum profit decreases, and the strategy becomes less risky. Increasing both strike prices makes the strategy delta neutral and makes vega and gamma slightly more negative.

As the time to expiration increases, the prices of both options increase and profits increase.

(5) Equivalent Positions:

Long stock plus write call with K_1 plus write call with K_2

Write Put with K_2 plus write call with K_1

6) Additional Comments: The short strangle is a slightly less risky version of the short straddle. The amount that the stock price must move for the position to suffer a loss can be increased by increasing the distance between the strikes. The strangle described above uses OTM options, but the ITM

version has exactly the same profit and loss characteristics. The OTM version is preferred because it requires lower initial margin ($10 versus $20 for the given example), and it has no assignment risk.

Write OTM Call

(1) Description: Write a call option contract on stock ZYX with strike price *K* greater than the current stock price and with time to expiration, *t*.

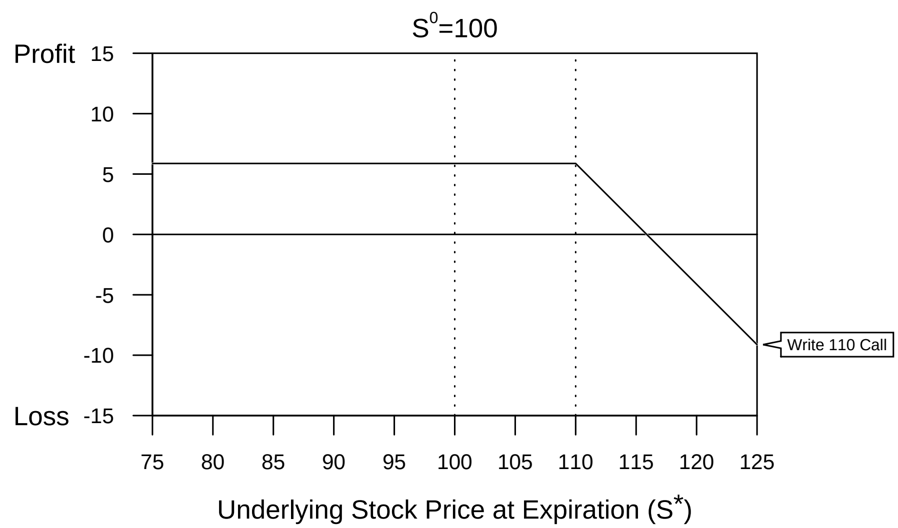
Example:

Write 1 ZYX Jun 110 Call contract for $587.50

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 63.

Figure 63. Payoff Diagram for Written OTM Call



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = $110

Maximum Profit:	C		$5.875
Maximum Loss:	Unlimited		
Breakeven Point:	S* = K + C		$115.875
Profit versus S*:	Profit = C	for S* ≤ K	$5.875
	Profit = (K - S*) + C	for S* > K	
Profit versus t*:	Profits increase as the call option expires		

(4) Effects of Varying Option Parameters: As the strike price increases and the call becomes more OTM, profits and the likelihood of loss both decrease, and the strategy becomes less risky. The strategy becomes neutral-bearish as the strike price decreases. As the strike price increases, delta, vega, and gamma all become less negative.

As the time to expiration increases the call option price and profits increase.

(5) Equivalent Positions: Short stock plus write put

(6) Additional Comments: The written OTM call is simply half of the short OTM strangle. Losses are only incurred if the stock price undergoes a large price increase. In return for the lower risk, profits are reduced by one of the option premium.

Writing calls once again illustrates the flexibility of options. When the written call is ITM the strategy allows an investor to profit from a bearish stock outlook because delta approaches -1. As the strike price increases, the risk of the bearish strategy decreases because delta increases and losses decrease if the stock price increases. Profits correspondingly decrease if the outlook is accurate and the stock price decreases. As the call becomes OTM the risk and return characteristics change so much that the strategy becomes more suitable for meeting a neutral objective than for meeting the original bearish objective. However, since even far OTM calls still have some delta, it is necessary to buy some of the underlying stock to achieve delta neutrality. As stock is added to the position, the payoff begins to resemble that of a short straddle.

Write OTM Put

(1) Description: Write a put option contract on stock ZYX with strike price *K* less than the current stock price and with time to expiration, *t*.

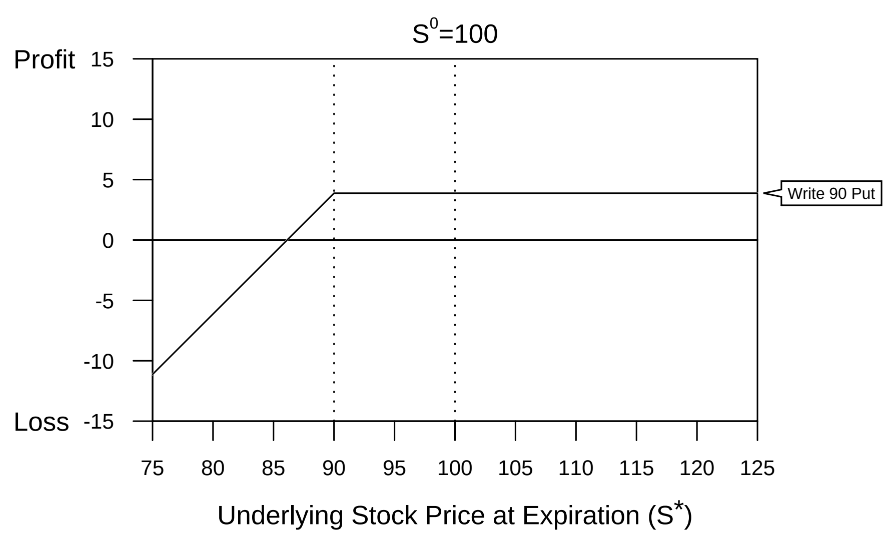
Example:

Write 1 ZYX Jun 90 Put contract for $387.50

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 64.

Figure 64. Payoff Diagram for Written OTM Put



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = \$90

Maximum Profit:	P		\$3.875
Maximum Loss:	(K - P)		\$86.125
Breakeven Point:	S* = K - P		\$86.125
Profit versus S*:	Profit = (S* - K) + P	for S* < K	
	Profit = P	for S* ≥ K	\$3.875
Profit versus t*:	Profits increase as the put option expires		

(4) Effects of Varying Option Parameters: As the strike price decreases and the put becomes more OTM, profits and the likelihood of loss both decrease, and the strategy becomes less risky. The strategy becomes neutral-bullish as the strike price increases. As the strike price decreases and the put becomes more OTM, delta decreases and vega and gamma become less negative.

As the time to expiration increases the put option price increases and profits increase.

(5) Equivalent Positions: Long stock plus write call.

(6) Additional Comments: The written OTM put is the other half of the short OTM strangle as discussed in the previous strategy. Losses are only incurred if the stock price undergoes a large price decrease. In return for the lower risk, profits are reduced by the premium of the missing call. Since even far OTM calls still have some delta, it is necessary to short some of the underlying stock to achieve delta neutrality.

The initial margin for writing an uncovered OTM option is the value of the option plus 20% of the underlying stock price minus the amount that the option is OTM. The proceeds from the sale of the option can be applied to the margin requirement so the true margin cost is the latter amount. If the amount that the option is OTM exceeds 10% of the underlying stock price, then the margin is the option value plus 10% of the underlying price. So if S^0 is \$100 and the call strike is \$110 or more, or if the put strike is \$90 or less, then the initial margin for either option is \$10. Since the cost of establishing the position in either option is the same, it is better to write the higher priced call unless the risk of a stock price increase outweighs the higher return.

Long Butterfly Call or Put Spread

(1) Description: Buy a call option with a given strike price K_1, buy a second call option with a higher strike price K_3, and write 2 call options with a strike price K_2 that is midway between the other two. All four call options have the same time to expiration, and the strike price of the written options is usually close to the current stock price. The position is referred to as a long K_1-K_2-K_3 call butterfly.

Example:

A long 90-100-110 Call Butterfly:

Buy 1 ZYX Jun 90 Call contract for $1,562.50

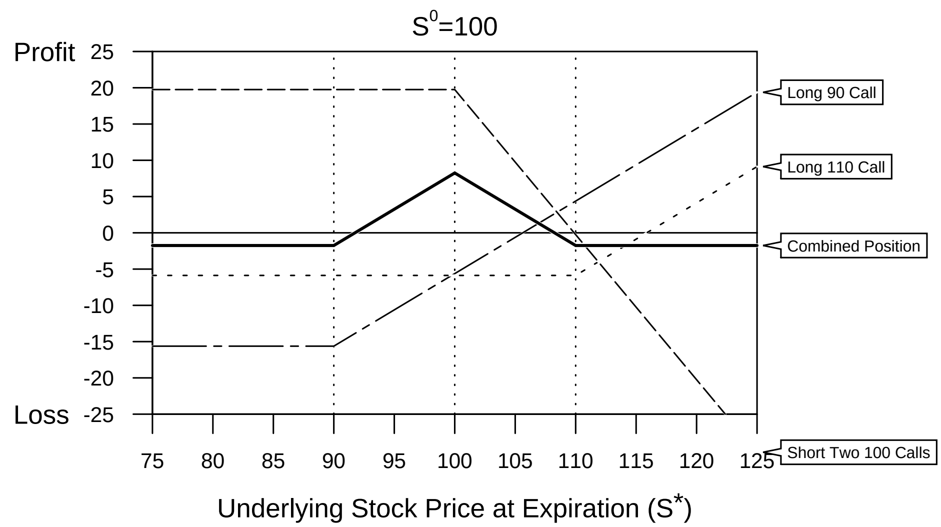
Buy 1 ZYX Jun 110 Call contract for $587.50

Write 2 ZYX Jun 100 Call contracts for $1,975.00

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 65.

Figure 65. Payoff Diagram for the Long Butterfly Call Spread



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = $105.

Maximum Profit:	$(K_2 - K_1) + (2C_2 - C_1 - C_3)$		$8.25
Maximum Loss:	$(2C_2 - C_1 - C_3)$		$1.75
Breakeven Points:	$S^* = K_1 - (2C_2 - C_1 - C_3)$ and		$91.75 and $108.25
	$S^* = (2K_2 - K_1) + (2C_2 - C_1 - C_3)$		
Profit versus S*:	Profit = $(2C_2 - C_1 - C_3)$	for $S^* \leq K_1$	
	Profit = $(S^* - K_1) + (2C_2 - C_1 - C_3)$	for $K_1 < S^* \leq K_2$	
	Profit = $(2K_2 - K_1 - S^*) + (2C_2 - C_1 - C_3)$	for $K_2 < S^* \leq K_3$	$3.25
	Profit = $(2K_2 - K_1 - K_3) + (2C_2 - C_1 - C_3)$	for $S^* > K_3$	
Profit versus t*:	Profits increase as the options expire		

(4) Effects of Varying Option Parameters: The long butterfly spread is a lower risk and return alternative to the short straddle. For the ZYX example, the maximum payoff is only $8.25 versus $17.875 for the K = 100 straddle. However, the maximum loss is limited to the net sum of the option prices which at $1.75 is less than 2% of the underlying price compared with unlimited loss for the straddle. Like the short straddle the payoff is a maximum when the stock price at expiration equals the strike price of the written options. Therefore, the strategy can be made neutral-bullish or neutral-bearish by slightly increasing or decreasing all of the strike prices by the same amount. As the distance between the strikes of the purchased

options increases, the maximum profit and loss increase, and the breakeven points become farther apart. The position represented by the example is delta neutral, but vega and gamma are only 10% as large as vega and gamma of a straddle or strangle.

As the time to expiration increases, the prices of the written options increase slightly more than the prices of the long options, so profits increase, however, the effect is small.

(5) Equivalent Positions: There are 11 possible equivalent positions for this strategy, but we only list the three that consist entirely of options. Let C(K) and P(K) denote a call and put with strike price K. A minus sign denotes a written option. Then the equivalent positions are:

P(90) - P(100) - C(100) + C(110)

C(90) - P(100) - C(100) + P(110)

P(90) - 2P(100) + P(110)

Since so many different options can be used to implement the strategy, then the likelihood of finding mispriced options and increasing profits is that much greater.

(6) Additional Comments: The long butterfly spread has interesting time decay properties. Even though the net sum of the option prices is positive, the profits increase as the options expire because the position vega is positive.

The butterfly requires four options, and the transaction costs can often exceed the profits. Therefore, the spread is commonly used by professional traders who build it with mispriced options to increase the payoff.

Note from the third equivalent position above that the same strategy can be implemented with put options and is then called a long butterfly put spread. The payoff characteristics are almost identical to that of the call spread.

Finally, note that a long K_1-K_2-K_3 butterfly is actually two spreads. The long K_1 call-short K_2 call is a vertical bull call spread, and the long K_3 call-short K_2 call is a vertical bear call spread.

Long Condor Call or Put Spread

(1) Description: Buy a call option with a given strike price K_1, and buy a second call option with a higher strike price K_4. Write two call options with strike prices K_2 and K_3 that are between K_1 and K_4, and such that K_3 is higher than K_2. The distance between K_1 and K_2 equals the distance between K_3 and K_4, and the price of the underlying usually lies between the strikes of the written options. The position is referred to as a long K_1-K_2-K_3-K_4 call condor and is the butterfly with the middle strike split.

Example:

A long 90-95-105-110 Call Condor:

Buy 1 ZYX Jun 90 Call contract for $1,562.50

Buy 1 ZYX Jun 110 Call contract for $587.50

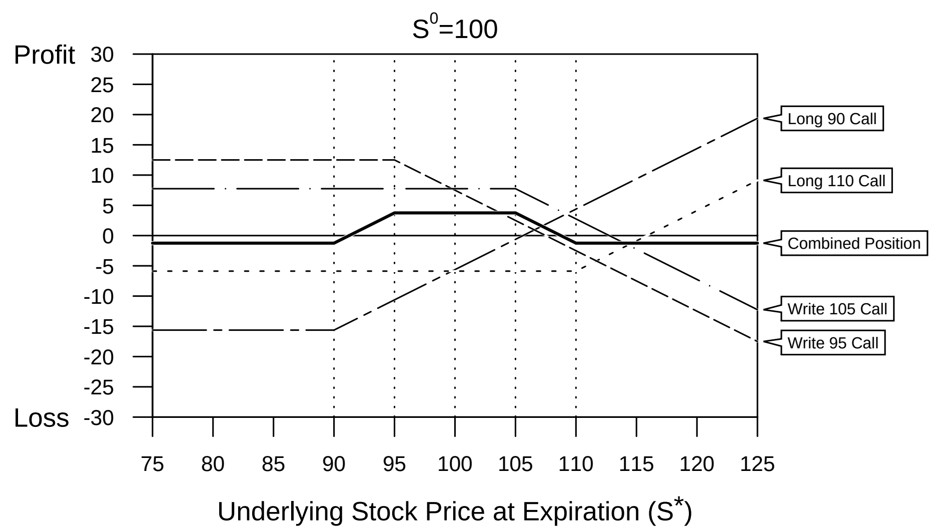
Write 1 ZYX Jun 95 Call contract for $1,250.00

Write 1 ZYX Jun 105 Call contract for $775.00

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 66.

Figure 66. Payoff Diagram for the Long Condor Call Spread



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = $105

Maximum Profit:	$(K_2 - K_1) - (C_1 + C_4 - C_2 - C_3)$		$3.75
Maximum Loss:	$-(C_1 + C_4 - C_2 - C_3)$		$1.25
Breakeven Points:	$S^* = K_1 + (C_1 + C_4 - C_2 - C_3)$ and		$91.25 and $108.75
	$S^* = (K_3 + K_2 - K_1) - (C_1 + C_4 - C_2 - C_3)$		
Profit versus S*:	Profit = $-(C_1 + C_4 - C_2 - C_3)$	for $S^* \leq K_1$	
	Profit = $(S^* - K_1) - (C_1 + C_4 - C_2 - C_3)$	for $K_1 < S^* \leq K_2$	
	Profit = $(K_2 - K_1) - (C_1 + C_4 - C_2 - C_3)$	for $K_2 < S^* \leq K_3$	$3.75
	Profit = $(K_3 - S^*) + (K_2 - K_1) -$		
	$(C_1 + C_4 - C_2 - C_3)$	for $K_3 < S^* \leq K_4$	
	Profit = $(K_2 - K_1) + (K_3 - K_4) -$	for $S^* > K_4$	
	$(C_1 + C_4 - C_2 - C_3)$		
Profit versus t*:	Profits increase as the options expire		

(4) Effects of Varying Option Parameters: The payoff diagram of the long condor spread resembles those of the short strangle and the long butterfly, and the strategy is a lower risk version of both. The maximum payoff is

\$3.75 versus \$9.75 for the 90-110 strangle and \$8.25 for the 90-100-110 call butterfly. The maximum loss is limited to the net sum of the option prices which is \$1.25 versus \$1.75 for the butterfly. The payoff is a maximum when the stock price at expiration lies between K_2 and K_3, the strike prices of the written calls. The strategy can be made neutral-bullish or neutral-bearish by slightly increasing or decreasing all of the strike prices by the same amount. As the distance between all of the strikes increases, the maximum profit and loss increase, and the breakeven points become farther apart. The position represented by the example is delta neutral, but like the butterfly, vega and gamma are only about 10% as large as vega and gamma of a straddle or strangle.

As the time to expiration increases, the prices of the written options increase slightly more than the prices of the long options, so profits increase a small amount.

(5) Equivalent Positions: There are 15 possible equivalent positions for this strategy, but we list only the five that consist entirely of options. As before, let C(*K*) and P(*K*) denote a call and put with strike price *K*. A minus sign denotes a written option. Then the equivalent positions are:

P(90) - P(95) - C(105) + C110)

P(90) - C(95) - P(105) + C(110)

C(90) - P(95) - C(105) + P(110)

C(90) - C(95) - P(105) + P(110)

P(90) - P(95) - P(105) + P(110)

Since so many different options can be used to implement the strategy, then the likelihood of finding mispriced options and increasing profits is that much greater.

(6) Additional Comments: The same considerations of time decay and transaction costs that applied to the butterfly spread also apply to the condor. The condor also has an equivalent position using all puts, and can also be viewed as the combination of a vertical bull and vertical bear call spread.

Long Horizontal Call or Put Spread

(1) Description: Buy a call option with a given strike price *K* and time to expiration, t_2, and write a second call option with the same strike price but a shorter time to expiration, t_1.

Example:

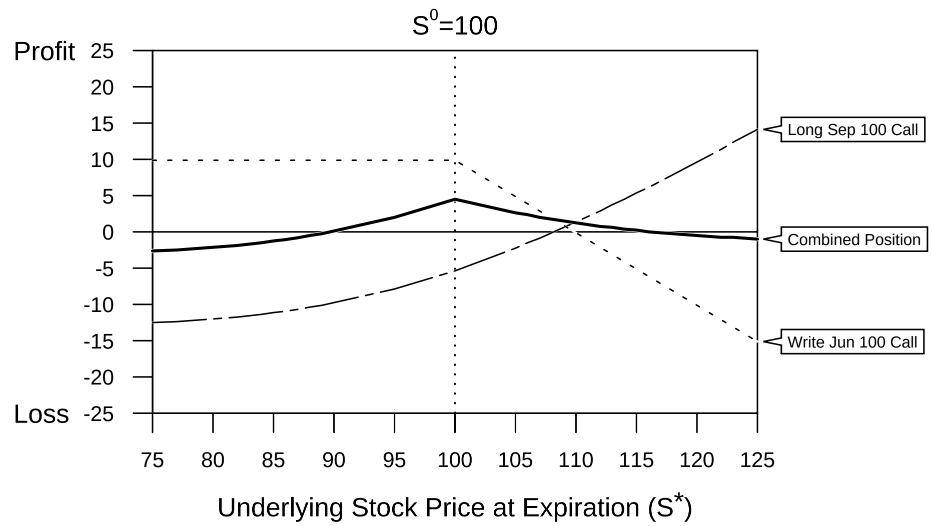
Buy 1 ZYX Sep 100 Call contract for $1,287.50

Write 1 ZYX Jun 100 Call contract for $987.50

Current price of ZYX stock is $100 per share.

(2) Payoff Diagram: See Figure 67.

Figure 67. Payoff Diagram for the Long Horizontal Call Spread



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = $105.

Maximum Profit:		$4.50
Maximum Loss:	(C_2 - C_1) on downside; less on upside	$3.00 and $1.625
Breakeven Point:		$89.875 and $116
Profit versus S*:		$2.625
Profit versus t*:	Profits increase as the options expire	

(4) Effects of Varying Option Parameters: As the strike price decreases and the calls become more ITM, the strategy becomes neutral-bearish because the stock price must decrease slightly for the spread to yield the maximum profit. Similarly, the strategy becomes neutral-bullish as the strike increases. For fixed t_2 the maximum profit increases and the maximum loss decreases as t_1, the shorter expiration time of the written option increases.

(5) Equivalent Positions:

Long stock plus write call with t_1 plus buy put with t_2

Write put with t_1 and buy put with t_2

(6) Additional Comments: The horizontal call spread is also known as a calendar or time spread. The payoff of this strategy most resembles that of

the long butterfly spread. Note from (5) that the same strategy can be implemented with a long put with a given maturity date and a written put with a closer maturity date. The long horizontal put spread is cheaper to establish than the call spread, and often has more favorable risk and return characteristics. The ZYX Sep-Jun 100 put spread, for example, has the same maximum profit as the corresponding call spread, but the maximum downside loss is only $1.875 compared with $3.00 for the call spread.

Note that since the long option has a longer lifetime than the written option, it has a larger vega and a smaller gamma. Therefore, this strategy actually has a positive vega and a negative gamma. So the long horizontal spread profits when the implied volatility of the longer term option increases more than the implied volatility of the shorter term option. That is, the strategy should be implemented when long term implieds are too low and short term implieds are too high.

Ratio Call Spread

(1) Description: Buy a call option with strike price K_1 and write two different call options with a greater strike price, K_2. All three options have the same time to expiration, t.

Example:

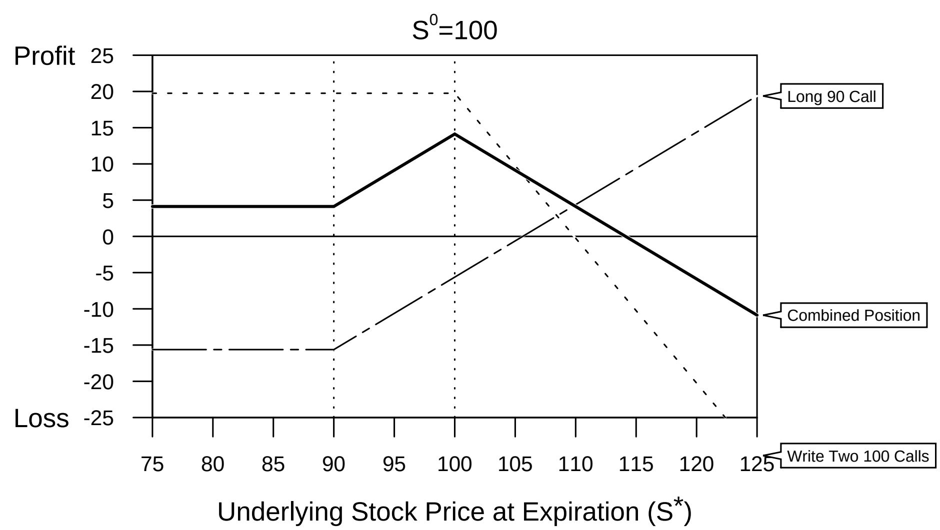
Buy 1 ZYX Jun 90 Call for contract for $1562.50

Write 2 ZYX Jun 100 call contracts for $1975.00

Current price of ZYX stock is $100 per share

(2) Payoff Diagram: See Figure 68.

Figure 68. Payoff Diagram for the Ratio Call Spread



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume S^* = \$105.

Maximum Profit:	$(K_2 - K_1) + (2C_2 - C_1)$		\$14.125
Maximum Loss:	Unlimited		
Breakeven Point:	$S^* = (2K_2 - K_1) + (2C_2 - C_1)$		\$114.125
Profit versus S*:	Profit = $(2C_2 - C_1)$	for $S^* \leq K_1$	
	Profit = $(S^* - K_1) + (2C_2 - C_1)$	for $K_1 < S^* \leq K_2$	
	Profit = $(2K_2 - K_1 - S^*) + (2C_2 - C_1)$	for $S^* > K_2$	\$9.125
Profit versus t*:	Profits increase as the options expire		

(4) Effects of Varying Option Parameters: Since this is a delta neutral strategy, the written calls must have lower delta than the long call, so they must have a higher strike price. As the difference between the strikes increases, the maximum profit increases, as does the magnitude of the price move required for a loss. The value of the written side of the position should be greater than the value of the long side so that a profit results from a price move in either direction. The point of maximum loss occurs at the higher strike price, and the profit or loss limit on the downside occurs at the lower strike price. The position represented by the example actually has a negative delta of about -0.40. The position can be made delta neutral by decreasing the strike price of the long option and increasing the strike price of the written options which also makes vega and gamma more negative.

(5) Equivalent Positions: Buy a put with strike K_1 and write a put and a call with strike K_2

(6) Additional Comments: The Ratio Call Spread is a neutral stock outlook strategy, but the payoff is asymmetric. A stock price increase is less profitable than a price decrease, so the strategy actually satisfies a neutral—bearish stock outlook.

Ratio Put Spread

(1) Description: Write two puts with strike price K_1 and buy a third put with a higher strike price, K_2. All three options have the same time to expiration, t.

Example:

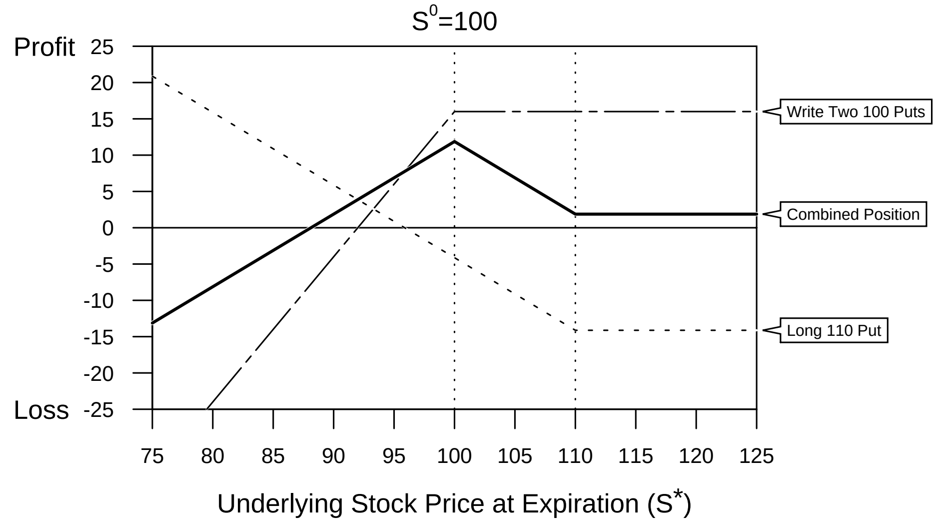
Write 2 ZYX Jun 100 Put contracts for \$1,600.00

Buy 1 ZYX Jun 110 Put contract for \$1,412.50

Current price of ZYX stock is \$100 per share

(2) Payoff Diagram : See Figure 69.

Figure 69. Payoff Diagram for the Ratio Put Spread



Source: Smith Barney Inc./Salomon Brothers Inc.

(3) Profit and Loss Analysis: Assume $S^* = \$105$.

Maximum Profit:	$(K_2 - K_1) + (2P_2 - P_1)$		\$11.875
Maximum Loss:	$(K_2 - 2K_1) + (2P_2 - P_1)$		-\$88.125
Breakeven Point:	$S^* = (2K_1 - K_2) + (2P_2 - P_1)$		\$88.125
Profit versus S*:	Profit = $(S^* + K_2 - 2K_1) - (2P_2 - P_1)$	for $S^* \le K_1$	
	Profit = $(K_2 - S^*) + (2P_2 - P_1)$	for $K_1 < S^* \le K_2$	
	Profit = $(2P_2 - P_1)$	for $S^* > K_2$	\$6.875
Profit versus t*:	Profits increase as the options expire		

(4) Effects of Varying Option Parameters: Since this is a delta neutral strategy, the written puts must have lower delta than the long put, so they must have a higher strike price. As the difference between the strikes increases, the maximum profit increases, as does the magnitude of the price move required for a loss. The value of the written side of the position should be greater than the value of the long side so that a profit results from a price move in either direction. The point of maximum profit occurs at the lower strike price, and the profit or loss limit on the upside occurs at the higher strike price.

The position represented by the given example actually has a positive delta of about 0.25. The position can be made delta neutral by increasing the strike price of the long option or decreasing the strike price of the written options. The former action makes vega and gamma more negative and the latter makes vega and gamma less negative.

(5) Equivalent Positions: Write a call and a put with strike K_1 and buy a call with strike K_2

(6) Additional Comments: The Ratio Put Spread is a neutral stock outlook strategy, but the payoff is asymmetric. A stock price decrease is less profitable

than a price increase, so the strategy actually satisfies a neutral—bullish stock outlook.

B. Arbitrage Strategies Using Synthetics

1. Introduction

The put-call parity relationship between European style options on non-dividend paying stocks was introduced in Chapter Three and can be written as

$$S + P = C + PV(K)$$

where S, P, and C are the initial prices of the underlying stock, put option, and call option, respectively, and PV(K) is the present value of the strike price of the options. PV(K) is simply the amount invested initially at the risk free rate that will equal K at expiration.

This relationship states that buying one share of stock for S and one put option for P produces the same returns at expiration as buying one call option for C and investing the remaining ($S + P - C$) at the riskless rate. Thus the returns of any one of the basic equity securities can be duplicated by taking a long or short position in the other two and by borrowing or lending. For example, the returns from buying a share of stock can be duplicated by buying a call, writing a put, and buying a riskless discounted Treasury bond that is worth K at options expiration. The long call plus written put plus long bond position is called the **synthetic equivalent** of the long stock. The corresponding synthetic equivalent of short stock is long put plus written call plus short bond. Similarly, each of the two call and put positions have synthetic equivalents composed of stock, the bond, and the other option. The six possible synthetic positions can be summarized as:

- synthetic long stock = long call + write put + long bond
- synthetic short stock = write call + long put + short bond
- synthetic long call = long stock + long put + short bond
- synthetic written call = short stock + write put + long bond
- synthetic long put = short stock + long call + long bond
- synthetic written put = long stock + write call + short bond.

To gain further insight into these equivalent positions, consider synthetic long stock. If the stock price at expiration, S^*, is below the strike price, then:

- The long call expires worthless,
- The bond is worth K,

- The put finishes ITM and the writer is assigned and must buy the stock for *K*.

If *S** at expiration is above the strike price, then:

- The written put expires worthless,
- The bond is worth *K*,
- The long call finishes ITM and the owner exercises it and buys the stock for *K*.

Neglecting for the moment the case where *S** is exactly equal to the strike price, the long synthetic stock position at expiration results in ownership of stock worth *S** which is the same result produced by a long position in the actual stock.

Whenever an asset trades in more than one market the possibility of arbitrage exists. Arbitrage is a trading strategy that generates riskless profits with no initial investment. Arbitrage is implemented by simultaneously buying and selling an asset at different prices in two places. For example, assume that ZYX stock is selling for $100 per share in New York and for $101 in Chicago. The arbitrageur can borrow $100, buy ZYX in New York, simultaneously sell it in Chicago, repay the loan, and lock in a $1 profit with no risk and no initial investment. However, the transactions are likely to drive the price of ZYX up in New York and down in Chicago until they are equal at both exchanges. So arbitrage opportunities, if present at all, cannot last for long. In fact, the very existence of arbitrageurs insures equilibrium among asset prices and market efficiency.

Since stock has a synthetic equivalent in the options and bond markets, then arbitrage trading between the two is possible. For example, if a call option is overpriced, then so is the synthetic stock that contains the call. Furthermore, selling the overpriced synthetic in the options market and buying the actual stock in the equity market should lock in a riskless profit equal to the amount by which the synthetic is overpriced.

The remainder of this section deals with these arbitrage strategies which involve trading between the actual and synthetic stock markets. It should be noted, however, that these strategies are generally not practiced by the average institutional or retail investor because of their complexity and high transaction costs. They are the domain of the professional traders and professional dealers or market makers who trade in the pits of the major exchanges. Nevertheless, these strategies are of interest because they play an important economic role in providing liquidity and price efficiency, and because they illustrate many important relationships among options and the underlying asset.

2. Arbitrage Strategies

In this section we will discuss four popular options arbitrage strategies:

- Conversions
- Reversals
- Box Spreads
- Jelly Roll Spreads

a. Conversions

A conversion involves buying the actual underlying asset and simultaneously shorting the synthetic. For stock the latter equals (C - P) so a stock conversion involves buying stock, writing a call, and buying a put. A call conversion involves buying a call, shorting the stock, and writing a put. A put conversion involves buying a put, buying the stock and writing a call. A trader implements a stock conversion if the synthetic stock is overvalued which can occur if the call is overvalued, the put is undervalued, or both.

We can use a rearranged version of the put-call parity relationship to determine if the synthetic stock is overvalued:

$$S - PV(K) = C - P$$

The present value of the strike price, PV(K), is simply the strike price, K, times the discount factor:

$$S - Ke^{-rt} = C - P$$

where: r = the annual riskless interest rate, and

t = the time remaining to expiration in years.

Note that we have used continuously compounded interest in the expression above which accounts for the number e and the exponential function, e^{-rt}. When interest is continuously compounded, the quantity e^{rt} is analogous to the quantity $(1+r)^t$, the quantity e^{-rt} is analogous to the quantity $(1+r)^{-t}$, and the actual term interest is equal to $(e^{rt}-1)$ times the principal.

The synthetic stock can have any strike price as long as it is the same for both options. This means that every listed put-call pair with the same underlying and the same expiration date can be evaluated for mispricing.

Assume that for the ZYX Jun 95 calls and puts we have the following:

C = 13.000

$P =$ 5.500

t = 150 days,

r = 5.0% per year, and

S, the current price of ZYX. is \$100 per share.

Then the put-call parity relationship gives:

$$S - Ke^{-rt} = C - P$$

$$100 - 95(e^{-0.0210}) = 13.000 - 5.500$$

$$100 - (95)(0.980) = 7.500$$

$$6.932 < 7.500$$

So the synthetic stock is overvalued by (\$7.500 - \$6.932) = \$0.568. A market maker seeking to profit from this mispricing would execute the following trades:

- Sell the ZYX Jun 95 Call and receive \$13.000
- Buy the ZYX Jun 95 Put and pay \$5.500
- Borrow the present value of the strike price which equals \$93.068
- Buy 1 share of ZYX stock for \$100

The net cash proceeds from the four transactions above are:

Proceeds = (13.000 - 5.500 + 93.068 -100) = \$0.568

In addition, the trader owns one share of ZYX stock.

Assume that the price of ZYX is \$105 on the date that the options expire. Then the following transaction analysis applies at expiration:

- The call expires ITM, the trader is assigned, and he or she must sell the stock for \$95: Net = + \$95
- The put expires worthless: Net = 0
- The proceeds of the loan plus interest is repaid: Net = - \$95

The net proceeds from the three transactions above are \$0 and the stock is assigned. The trader has thus realized \$0.568 in profits with no risk and no initial investment. The profits are equal to the amount by which the synthetic stock was overvalued.

The profit and loss analysis of the conversion can be simplified by once again using the put-call parity equation:

$$S + P = C + Ke^{-rt}$$

Multiplying both sides of the equation by e^{rt}:

$$Se^{rt} + Pe^{rt} = Ce^{rt} + K$$

Subtracting the initial stock price, S, from both sides of the equation:

$$-S + Se^{rt} + Pe^{rt} = Ce^{rt} + K - S$$

Rearranging we get:

$$(C - P)e^{rt} + (K - S) = S(e^{rt} - 1)$$

The first term in the equation above is the positive proceeds of the written call and long put transactions plus interest. If the stock price at expiration is less than the strike price, then the long put expires ITM, the market maker exercises the put, sells the stock and receives *K*. If the stock price at expiration is greater than the strike price, then the written call expires ITM, the market maker is assigned, and the stock must be sold for *K*. In either case, the amount received for the stock by either exercising the call or being assigned the put is *K*. The second term then is the difference between the selling price of the stock and the buying price. The third term is the interest foregone on the money used to buy the stock. If the synthetic is overvalued then the left hand side of the equation above is greater than the right hand side, and the profits of the conversion are given by:

$$\Pr ofits = (C - P - S)e^{rt} + K$$

b. Reversals

A reversal or reverse conversion involves shorting the real underlying asset and simultaneously buying the synthetic. For stock the latter equals (C - P) so a stock reversal involves shorting stock, buying a call, and writing a put. A call reversal involves writing a call, buying the stock, and buying a put. A put reversal involves writing a put, buying a call, and shorting stock. A trader implements a stock reversal if the synthetic stock is undervalued which can occur if the call is undervalued, the put is overvalued, or both.

Again we use the put-call parity equation to determine if the synthetic stock is undervalued. A reversal is profitable if:

$$S - Ke^{-rt} > (C - P)$$

The profits from a reversal are given by:

$$\Pr ofits = -(C - P)e^{rt} + (S - K) + S(e^{rt} - 1)$$

The first term in the equation above is the negative proceeds of the long call and written put transactions plus carrying cost or foregone interest. If the stock price at expiration is less than the strike price, then the written put expires ITM, the market maker is assigned, and the stock must be purchased for *K*. If the stock price at expiration is greater than the strike price, then the long call expires ITM, the market maker exercises the call, buys the stock and pays *K*. In either case the cost of buying the stock by either exercising the call or being assigned the put is *K*. The second term then is the difference between the short sale proceeds and the cost of buying back the stock. The third term is the interest received on the proceeds of the short sale.

Conversion and Reversal Risks

We have been discussing conversions and reversals within the context of riskless arbitrage, but these trades are not really riskless. In particular, conversions and reversals are subject to three types of risk which can erode the already thin profits: Pin risk, interest rate risk, and early exercise risk.

1) Pin Risk

Pin risk is the risk that the underlying stock price will equal or be "pinned" at the strike price when the options expire. If the stock price is not pinned at expiration, the trader of a conversion or reversal is assured of selling or buying the stock at the strike price. If the stock price is pinned then neither option will be exercised, and the trader must sell or buy stock in the open market on expiration day and is subject to market risk. Furthermore, the right to exercise an option is usually included in the original option premium, so it is cheaper to obtain stock by exercising than by purchasing it in the open market. Pin risk is best removed by closing out the position early if it appears that the stock might close at the strike price on expiration day.

2) Interest Rate Risk

An increase in the interest rate reduces the profits of a conversion because the carrying costs of the long stock and the long call increase. Similarly, a decrease in the interest rate reduces the profits of a reversal because the interest received on the proceeds of the short stock and the written call decrease. The interest rate risk of a conversion can be hedged by simultaneously establishing a position in a reversal that uses options from a different class. Then if interest rates increase, the profits lost on the conversion will be offset by an equal gain in the profits of the reversal.

3) Early Exercise Risk

A reversal involves a written put which is always at risk of being exercised early, especially if it is deep ITM, pays no dividend, and the stock price undergoes a large decline soon after the position is established. If the put is exercised early, then the market maker is assigned and must buy back the stock sooner than planned. The remaining interest on the proceeds of the short sale is lost and overall profits are reduced.

c. Box Spread

Assume that the ZYX Jun 85 call is cheap and the ZYX Jun 115 call is expensive. A market maker can profit from both mispricings with very little risk by simultaneously establishing a conversion with the Jun 115 call and put and a reversal with the Jun 85 call and put. The conversion results in writing the overpriced 115 call and the reversal results in buying the underpriced Jun 85 call. Buying synthetic stock using options with a given strike price and simultaneously shorting synthetic stock using options with a higher strike price is a long box spread. A short box spread consists of buying the synthetic stock with the higher strike price. All four options have the same time to expiration.

There is no net stock transaction in a box spread because the long stock in the conversion cancels the short stock in the reversal. The position in the example involves a long 85 call and a written 115 call, and a long 115 put and a written 85 put. So a long box spread is simply a vertical bull call spread and a vertical bull put spread. Similarly, a short box spread is a vertical bear put spread and a vertical bear call spread.

The profits of a box spread are simply the sum of the profits of the conversion and the reversal and are given by:

$$\text{Pr}\,ofits = (C_1 - P_1)e^{rt} - (C_2 - P_2)e^{rt} + (K_1 - K_2)$$

where the subscripts 1 and 2 refer to the lower and higher strike, respectively.

d. Jelly Roll Spread

A jelly roll spread allows a market maker to profit from mispriced options that have the same strike price but different expiration dates. Suppose that the ZYX Sep 85 call is cheap and the ZYX Jun 85 call is expensive. A market maker can profit from both mispricings by simultaneously establishing a conversion with the Jun 85 call and put and a reversal with the Sep 85 call and put. The conversion results in writing the overpriced Jun call and the reversal results in buying the underpriced Sep call. Buying synthetic stock using options with a given time to expiration and simultaneously shorting synthetic stock using options with a shorter time to expiration is a long jelly roll spread. A short jelly roll consists of buying the synthetic stock with the earlier expiration date. All four options have the same strike price.

Like the box spread there is no net stock transaction in the jelly roll. A long jelly roll is actually two spreads. The first spread consists of a long call with time to expiration t_2, and a written call with the shorter time to expiration t_1. The second spread consists of a long put with time to expiration t_1 and a written put with the longer time to expiration t_2. Thus, a long jelly roll is simply a long horizontal call spread plus a short horizontal put spread. Similarly, a short jelly roll is a long horizontal put spread plus a short horizontal call spread.

C. Strategies Using Stock Index Options and Options on Stock Index Futures

1. Introduction

The previous sections of this chapter described options strategies that allowed investors to modify the risk and return characteristics of individual stocks. However, most institutional equity investors hold portfolios that contain many stocks from numerous countries, economic sectors, and industry groups. These portfolios are designed to replicate the performance of various broadly diversified equity markets. So we now turn to those strategies that use index options to modify the risk and return characteristics of entire portfolios and in particular, of market or benchmark portfolios. These strategies are very similar to the ones already discussed, but the options used to implement them are quite different. The underlying assets of these options are not individual stocks but are broad stock market indexes and futures contracts on the indexes.

2. Stock Indexes

A stock index is a number that is proportional to the market value of the portfolio of stocks represented by the index. Since the market value is in turn a function of the individual stock prices, then an index must also be proportional to some function of the constituent prices. The well known and frequently quoted Dow Jones Industrial Average is proportional to the simple sum of the prices of its 30 stocks. Most stock indexes, like the Standard & Poor's 500 Composite Stock Price Index, are proportional to the total market value or capitalization of the stocks. Regardless of the exact relationship, all stock indexes increase or decrease as the prices and market values of the member stocks rise and fall.

Stock indexes then measure the price performance of a portfolio of stocks. Some indexes, such as the Salomon Smith Barney World Equity Indexes, are designed to measure the performance of the entire global equity market and consist of several thousand stocks. Other indexes are narrower in scope and represent smaller market segments such as countries, industries, small companies, etc. An efficient way for an investor to invest in the broad market or in one of the narrower segments is to buy the stocks that comprise the index and in the same proportions as in the index. Without stock index options and stock index futures this is the only way that the performance of a market index can be replicated. However, stock index options provide the investor with valuable alternatives for gaining exposure to and modifying the risks of the broad equity market.

3. Stock Index Options

The first exchange listed stock index options were those on the Standard & Poor's 100 (OEX) stock index which began trading on the CBOE in March of 1983. As of March of 1998, over 100 stock index options were listed on 28 separate exchanges in 20 countries. We will discuss stock index options by describing some of their more important properties and some of the ways in which they differ from ordinary stock options.

a. Underlying Security and Contract Unit

The underlying security of an ordinary stock option is the stock itself, usually in 100 share units. The underlying security of a stock index option is the stock index. The value of the underlying is the value of the index times a multiplier which is usually 100. So the index is treated like a share of hypothetical stock whose price equals the index level, and each stock index option contract is an option to buy or sell 100 such shares.

b. Exercise Settlement Method

A stock call option contract stipulates that when the option is exercised, the owner must take physical delivery of 100 shares of the underlying stock in exchange for cash equal to 100 times the strike price of the option. Similarly a stock put option contract stipulates that upon exercise the owner must physically deliver 100 shares of the underlying stock and receive cash in the amount of 100 times the strike price. If the same rule applied to the settlement of stock index options, then the owner of a call would have to take delivery of the underlying index by accepting every stock in the index, in the same proportions as in the index, and with a total value equal to 100 times the index value. Obvious problems arise from this method of settlement. Delivery of the exact underlying requires delivery of odd lots and fractional shares. The logistics of transferring large volumes of shares on expiration day would overwhelm the exchanges and clearing house. Therefore, stock index options are settled **in cash**.

The mechanics of cash settlement are as follows. If an index call strike price is 500 and the index closes at 550 on expiration day, the call finishes 50 points ITM. Since each point is worth $100, the owner's account is credited with 100(550 - 500) = $5,000, and the writer's account is debited by the same amount. Similarly, if the index put is struck at 500 and the index closes at 450 on expiration day, then the put finishes 50 points ITM. The put owner's account is likewise credited with 100(500 - 450) = $5,000 and the put writer's account is debited by the same amount.

c. American and European Exercise Style

We have mentioned previously that all individual stock options traded on U.S. exchanges are American exercise style. In fact, every listed stock option in the world is American style except for those traded at the Copenhagen Stock Exchange, the Rio de Janeiro Stock Exchange, the Osaka Securities Exchange, and the Tokyo Stock Exchange. However, the vast majority of domestic and international stock index options are European style. The notable exceptions are the OEX traded at the CBOE, the FT-SE 100 index option traded at the London International Financial Futures and Options Exchange (LIFFE) (which can be European or American), and the CAC 40 index option traded at the Marche des Options Negociables de Paris (MONEP).

d. Early Exercise

In Section A of this chapter we outlined the conditions under which American style stock options may be exercised early. American style stock index options are subject to another early exercise scenario. The stocks that comprise an index can continue to trade on regional exchanges after the closing index value is computed which is usually at the 4:00 PM ET close of the NYSE. If some of these stocks decline in price during this interval, or even if they are expected to open lower the following morning, then the index can open lower. If the index opens down then so will any ITM call options on the index. If the expected decline is large enough, then it may be more profitable to exercise the calls before the usual 5:00 PM ET exercise deadline. The same scenario applies to ITM put options if some of the stocks in the index rise in price or are expected to open higher.

e. Arbitrage Trading Risk

If an OEX index call is overpriced, then a trader can theoretically profit by establishing a conversion. The trader writes the OEX call, buys the OEX put with the same strike and expiration date, and buys a portfolio of stocks which replicates the performance of the OEX index. If the call expires ITM, then the trader is assigned, and settles by making a cash payment of 100 times the difference between the index value and the strike price. If the put expires ITM, then the trader exercises and receives a cash payment of 100 times the difference between the strike price and the index value. Since the index options are settled in cash, the trader cannot get rid of the stock by delivering it to the call owner or the put writer. Instead the trader has to sell the stocks in the open market and bear the market risk as well as the transaction costs. If the market declines after the index options are exercised and before the stocks are sold, then the trader incurs a loss.

Another component of risk in conversions and reversals that use stock index options is the tracking error that arises from imperfect replication of the underlying index. It is often impractical and too expensive to buy or sell short every stock in the index at the proper weight. So traders usually substitute stock index futures or tracking portfolios that contain only some of the stocks in the index, and the resulting tracking error risk can significantly reduce profits.

4. Strategies Using Stock Index Options

The concepts that govern the use of individual stock options apply equally to the use of stock index options, so the strategies discussed in Section A can also be implemented with the latter. The major difference is that index options apply to strategies that reflect a view on the future price and volatility levels of the portfolio of stocks represented by the index rather than a view on those of a single stock. So stock options are appropriate for strategies concerned with individual stock selection, and index options are appropriate for strategies concerned with market portfolio management and asset allocation.

For example, speculators and long term investors can gain access to broad equity markets, economic sectors, and industry groups, both foreign and domestic, by purchasing index calls. Investors with bearish outlooks on these same markets can purchase index puts instead of shorting the many stocks that comprise the index.

Hedgers can reduce the risk of their market or industry portfolios by combining index puts with their equity holdings. Spreaders who seek excess returns with reduced risk can easily establish a long position in one market and a short position in another using index options.

Volatility traders can also use index options to implement the numerous long and short volatility strategies discussed in the first part of this chapter. Instead of profiting from an increase or decrease in the volatility of a single stock, these investors can profit from changes in the volatility of an entire market by trading only a small number of index options.

An investor always has the choice, however, of implementing a market strategy with a portfolio of individual options rather than with an index option. The investor will choose the position that best meets the investment objective and which can be established at the lowest cost. The remainder of this section mentions some of the considerations that enter into this decision.

a. Mispriced Options

Index options are more likely to deviate from their theoretical or fair values than stock options because they are linked to the corresponding stock index futures contract. Therefore, when the futures is overvalued, the index calls tend to be overvalued and the puts undervalued. So when the futures is overvalued it may be cheaper to implement a long call strategy with a portfolio of individual calls than with an index call. Conversely, a written put strategy may be cheaper to implement with an index put. The same considerations apply when the futures is undervalued resulting in cheap index calls and expensive index puts.

b. Assignment

If the position resulting from the implementation of a market strategy involves a portfolio of written options which are ITM at expiration, then the investor's portfolio can undergo significant change as stock is added or removed due to the assignment of puts and calls, respectively. Market hedge strategies that use index options can be disrupted by early assignment. Since the options are settled in cash, the investor is left with an unprotected portfolio of stock or futures upon assignment.

c. Tracking Error

If index options are used to hedge a portfolio of stocks, and the index underlying the option is not identical to the portfolio, then tracking error will arise. At some point if the cost of the tracking error is too high, it may be cheaper to implement the hedge with individual options.

5. Stock Index Futures

A futures contract is an obligatory agreement between two parties to buy or sell an asset at some future date for a price agreed upon now. Like options contracts, futures are usually traded on exchanges, have standardized contract terms, and are guaranteed by a clearing house that automatically becomes the counterparty to every transaction. Futures are bought or sold on margin which is usually only a few percent of the value of the underlying asset.

A stock index futures is a contract whose underlying asset is the portfolio of stocks represented by the index, and whose market value equals the index value times a multiplier. Like index options, stock index futures are settled in cash because of the problems associated with the physical delivery of a portfolio of stocks. Cash settled futures are usually settled or "marked to market" daily which entails adding gains to or subtracting losses from the accounts of the buyer and seller in cash on a daily basis.

As of March, 1998, 37 exchanges trade 79 stock index futures contracts whose underlying indexes represent the equity of 33 countries and 88% of the available capitalization of global equity. It is well beyond the scope of this Introductory Equity Options Guide to discuss the equity investment strategies that are implemented with index futures. Suffice it to say, that like options, they are valuable instruments for stock portfolio substitution, speculation, hedging, and risk management. (For more information on stock index futures, see the companion to this report, *The Salomon Smith Barney Introductory Guide to Stock Index Futures*).

6. Options on Stock Index Futures

An option on a stock index futures is a call or a put whose underlying asset is one stock index futures contract that expires on the month that is closest to the expiration month of the option. For example, at any given time the Chicago Mercantile Exchange (CME) lists four futures contracts on the S&P 500 Composite Index that expire during the four nearest calendar quarter months. The CME also lists six options on these futures at any given time that expire during the three nearest consecutive months plus the three next nearest months in the calendar quarterly cycle. So if June is the current month, then the June, July, August, September, December, and March S&P 500 futures options contracts are outstanding, and the June, September, December, and March S&P 500 futures contracts are outstanding. The quarterly futures contracts underlie the options with the corresponding expiration months, and the September futures underlies the July and August options.

When an option on a stock index future is exercised, the settlement involves both a cash payment and delivery of a futures contract. For example, the exerciser of a call receives a long position in the underlying futures contract that expires during the month closest to the option expiration month, plus cash equal to the futures multiplier times the difference between the current futures price and the strike price of the option. The exerciser of a put receives a short position in the appropriate futures contract plus cash equal to the futures multiplier times the difference between the put strike and the current futures price.

To illustrate, say an investor buys a Jul 1000 Call on the September S&P 500 futures. When the option expires in July, the September futures is trading at 1062.50 so the call owner exercises. He or she then receives one September futures contract plus cash equal to the futures multiplier times the difference between the futures price and the call strike, or 250(1062.50 - 1000) = $15,625.

The options that expire during the same month as the futures also expire on the same day. Therefore, if the option is exercised at expiration, the long or short futures position also expires. However, if an option on a futures that expires later than the option is exercised, the investor is left with an open futures position for as long as two months.

7. Strategies Using Options on Stock Index Futures

The strategies implemented with options on stock index futures are the same as those implemented with stock index options. However, options on futures are often the preferred tools for implementing these strategies. For example, an investor who seeks to profit from a decline in market volatility but who is uncertain about the direction of the market can implement one of the neutral market-decreasing volatility strategies such as a short straddle, long butterfly, ratio call spread, etc. The resulting positions should be delta neutral to hedge against any rise or fall in the market level. Delta hedging is most easily accomplished by buying or selling the amount of the underlying asset prescribed by the hedge ratio. Therefore, if the strategy is implemented with options on futures, delta hedging can be easily and accurately performed by buying or selling futures contracts. On the other hand, if the strategy is implemented with index options, delta hedging can only be performed by buying or selling a portfolio of stocks that replicates the underlying index. The strategy is thus subject to tracking error risk, higher transaction costs, and the problems associated with shorting a large portfolio of stocks.

Arbitrage strategies, such as conversions and reversals, are also implemented more efficiently in the index futures options market. Implementation of these strategies in the index options market requires buying or selling an index call, writing or buying an index put, and buying or shorting a large portfolio of stocks that tracks the underlying index. So the actual underlying may not be identical to the synthetic underlying.. However, the underlying asset of a futures option is the identical futures contract that also trades at an exchange.

Chapter Six

Exotic Options

Various OTC options exist whose properties and terms are much more complicated than those of the **plain vanilla** put and call options discussed in the first five chapters. These derivative structures are known as **exotic options** and are also referred to as **designer options** because investors customize or design the contract terms to meet their own very specific requirements. The primary reason that investors use exotics is that they are better for satisfying complicated risk and return preferences than are simple put and call options. In many cases, altering the standard features of simple options produces more complicated exotic features that make the option more cost effective for the user. The net effect is to either reduce the price of the exotic option relative to the conventional option, or tailor the payoff and make it *worth more* to the user for a given price. We could no doubt write a great deal of material on the myriad of exotic options that are currently available to investors. However, in this chapter we will limit the discussion to only the most commonly used exotics, and we also present an intuitive way to classify them.

At first reflection, the structure and terms of many exotics may appear to be overly complex. Nevertheless, many of these options have found a meaningful niche in the domain of institutional investing. The original users of exotics were corporate treasurers who sought innovative ways to manage currency and interest rate risk. More recently, some of these applications have found their way into the arena of global equity investing. By virtue of their added complexity, exotic options are traded in the over-the-counter markets. The more common structures are increasingly traded by a large number of dealers, who generally render reasonable liquidity at competitive prices.

We classify exotic options into three major categories. We first consider **price conditional** options whose values are a function of the price of the underlying at both expiration and prior to expiration. The payoff or value of these options will jump dramatically around specific price levels of the underlying asset. Price conditional options are also **path dependent** which means that their payoff depends not only upon the price of the underlying stock at expiration, but also the price of the underlying at various times prior to expiration.

The second category that we consider consists of options whose values are a function of the price of the underlying asset and the price of one or more other assets. We call these options **portfolio conditional** options, and their payoff depends upon the relationships among the prices of two or more assets.

Third, we consider **volatility conditional** options. These are options that allow the investor to either increase or decrease the uncertainty of the future volatility of the underlying asset. By altering the uncertainty of future volatility, the price of the option can also be altered to make the option either less expensive, more valuable, or both.

A. Price Conditional Options

As mentioned in Chapter Three, simple options are valued by assuming that the price of the underlying asset follows a lognormal distribution. The value of the option is a function of the probability of the underlying asset attaining any of the possible prices within that continuous distribution. However, an investor may desire an option that pays off only if the underlying asset price falls within a smaller range of all possible future prices. For example, a portfolio manager may desire the protection of an index put option but only if the price of the underlying asset falls below some predetermined level. Another manager may not want to pay for protection if the asset price remains above some specific level. Customized options that meet these additional requirements can be considerably cheaper than standard options.

1. Barrier Options

A **barrier option** is an option whose payoff is contingent upon the price of the underlying stock reaching a specified level or **barrier** during a specified time period. There are two types of barrier options, **knock-out options** and **knock-in options**. A knock-in option takes effect or becomes active only if the underlying stock price reaches the barrier. A knock-out option is originally active but automatically expires if the underlying stock price reaches the barrier. Some knock-outs are structured to pay an amount called the rebate when they expire

There are, in turn, two types each of knock-in and knock-out options. For knock-ins we have **up-and-in options** and **down-and-in options**. An up-and-in call or put becomes active only if the underlying stock price *increases* from its current value to the *higher* barrier value. Similarly, a down-and-in call or put becomes active only if the underlying stock price *decreases* from its current value to the *lower* barrier value.

For knock-out options we have **up-and-out options** and **down-and-out options**. An up-an-out call or put is originally active but automatically expires if the underlying stock price *increases* from its current value to the *higher* barrier value. Similarly, a down-and-out call or put is originally active but automatically expires if the underlying stock price *decreases* from its current value to the *lower* barrier value.

The price of a knock-in option is always less than or equal to the price of the regular option and decreases as the probability of it becoming activated decreases. So the price of a knock-in decreases as the barrier is set farther away from the current stock price. The price of a knock-out option is also always less than or equal to the price of the regular option and decreases as the probability of it expiring increases. So the price of a knock-out decreases as the barrier is set closer to the current stock price.

Consider the following examples of situations where cheaper barrier options may be more desirable than their standard option counterparts. Suppose that a risk averse investor has a bullish outlook on the general market, but is worried about a possible downside correction. He or she could purchase a down-and-out index call option that expires or gets knocked-out if the underlying index decreases to a specified level. The investor sets the knock-out barrier at an index level at which he or she no longer wants to remain long the market. A less bullish investor could purchase an up-and-in call option that becomes active or gets knocked-in only if the underlying index increases to a specified level. In this case, the investor sets the knock-in barrier at an index level at which he or she wants to become long the market.

Suppose that a bullish but cautious portfolio manager who is long the market desires some downside protection but feels that a market correction is unlikely. He or she could purchase a down-and-in index put option that becomes active or gets knocked-in if the underlying index decreases to a specified level. A more bearish manager could purchase an up-and-out index put that expires if the underlying index increases to a specified level.

2. Binary Options

A binary option is also known as a digital option or an all-or-nothing option, and pays a fixed amount if it expires ITM and pays nothing if it expires ATM or OTM. A binary option allows an investor to profit from a directional price move without having to worry about the magnitude of the move. The price of a binary is simply the probability that it will expire ITM times the specified payoff.

As an example of when a binary option may be appropriate, consider an investor who believes that the Federal Reserve is about to raise interest rates and that this in turn will cause the level of general stock prices to fall. However, the investor is uncertain of the magnitude of the possible decline. The investor can purchase a binary put option on the S&P 500 that pays a fixed amount if the index closes lower one week from now than today's close. Otherwise, the option expires worthless.

B. Portfolio Conditional Options

The exotic options in this second category have payoffs that are a function of the price of the underlying asset and the prices of one or more related assets. We consider **basket options**, **quanto options**, **contingent barrier options**, and **rainbow** or **outperformance options**.

1. Equity Basket Options

A **basket option** is simply a call or a put on a portfolio of stocks with a specified composition and weighting scheme. One alternative to a basket option is an index option. However, if an investor is seeking exposure to an obscure economic sector or industry group, or to an emerging country market, then none of the indexes that underlie listed index options is likely to be sufficiently correlated with the portfolio of interest. The investor thus incurs significant tracking error risk that can cost more than the additional cost of the basket option. A second alternative to a basket option is a collection of individual stock options. This alternative may be prohibitively expensive because of transaction costs and because the implied volatility of each option includes a large component of specific stock risk.

2. Quanto Options

A global equity investor with a well diversified portfolio of foreign stocks is subject to two distinct types of risk: each country's stock market risk and each country's currency risk. The latter is the risk that the currency in which the stock is denominated declines in value relative to the investor's native currency. Then the initial investment as well as any gains or dividends are worth less in the investor's currency.

For example, assume that a U.S. investor with a bullish outlook on the United Kingdom equity market buys a two month ATM call option on the FT-SE 100 Index from the London International Financial Futures and Options Exchange (LIFFE) for 2,400 GBP. If the index increases 5% over the next 30 days, then the option price increases to approximately 3,800 GBP. If the investor then sells the option, he or she realizes a profit of 1,400 GBP However, if the British pound decreases in value relative to the U.S. dollar over the period, then the pound now buys fewer dollars and some of the profit is lost.

Alternatively, the investor can buy a **quanto** call option. A quanto is an option whose underlying asset is denominated in one currency and whose payoff is made in another currency. The contract unit is "quantity adjusted" to keep the payoff independent of the exchange rate which is equivalent to fixing the exchange rate at the time the option is purchased. So in the example above, the price of the option increases by 1,400 dollars instead of pounds, and all currency risk is removed.

A quanto option can be more or less expensive than its listed counterpart depending upon the relationship between the riskless interest rates in the two countries. Interest rate differentials have a major impact on the hedging cost that is incurred by the dealer that takes the opposite side of a quanto option.

3. Contingent Barrier Options

The price and payoff characteristics of a **contingent barrier option** depend upon the prices of two assets. One is the underlying asset and the other is a reference asset. The contingent barrier is knocked-in or knocked-out when the price of the *reference* asset reaches a specified barrier during a specified time period.

For example, consider an equity investor who fears that a sudden increase in interest rates will drive down the level of the general stock market. An S&P 500 barrier put option that is contingent upon the interest rate level is a potentially effective vehicle for hedging a market portfolio. For example, the put option could be set to knock-in if the 30-year U.S. Treasury Bond yield surpasses a specified value any time during the option's lifetime. This contingent knock-in put is less expensive than a standard listed put option because it only exists if the rate rise occurs. Contingent barrier options are appealing to investors who are looking for ways to pay less premium. The investor should set the knock-in barrier at a yield at which he or she would want to hedge.

The price of the barrier option relative to a standard put option is partially a function of how close the barrier level is set to the current long bond yield. In general, the farther the barrier is set from the current yield, the lower the probability that the option will knock-in and therefore, the cheaper the knock-in option will be relative to the standard option.

4. Rainbow Options

Rainbow or outperformance options include **spread options** or **relative performance options**, **better-of** or **worse-of options**, and **exchange options**. The payoff of a rainbow option is a function of the difference between the total returns of two or more assets over a specified time period.

A **spread option** is structured to pay at expiration the greater of zero or the difference between the total returns of two specified assets times a notional amount. For example, an investor who believes that small capitalization stocks will outperform the broad market over the next six months purchases a notional $1,000,000 six month outperformance option on the Russell 2000 index relative to the S&P 500 index. Six months later the total returns of the Russell 2000 and S&P 500 are 20% and 10%, respectively. So the holder of the option receives (0.20 - 0.10) ($1,000,000) or $100,00 at expiration. If the S&P 500 outperforms the Russell during the same time period, then the option expires worthless. Spread options are also structured to pay at expiration the greater of zero or the difference between the *values* of two assets

A **better-of** option pays the difference between the price of an asset at expiration and its initial price, or the same difference for a second asset, or zero, whichever is greater. A **worse-of** option pays the lesser of the two differences, or zero, whichever is greater. In its most common form, the better-of option consists of two separate call options, each with a different underlying asset. Both calls are usually struck ATM, and the payoff is equal to the percent change of the better performing asset times a notional amount. The call on the worse performing asset has no payout, and both calls expire worthless if they finish OTM.

The price of the better-of option is greater than the price of either individual call option but is less than the sum of the prices of the two calls. The price of any outperformance option is a function of the correlation between the returns of the underlying assets with the price decreasing as the correlation increases.

A closely related option is the **exchange** option which gives the holder the right to exchange one asset for another at expiration. A better-of option is equivalent to a long position in either asset plus an exchange option.

Consider a global equity investor who wants to initiate a position in either Japan or Hong Kong. Figure 70 shows some of the alternatives that are available with outperformance options and standard options as a function of the investor's outlook for the performance of each country's market. The horizontal axis depicts the investor's outlook for the Hang Seng Index, and the vertical axis depicts his or her outlook for the Nikkei 225 index. Figure 71 shows the corresponding payoff for each of the nine possible positions. For example, if the investor is bullish on Japan and bearish on Hong Kong, then the spread option in the northeast quadrant is a practical choice.

Figure 70. Performance Option Strategies—Dependent on Views

Nikkei 225 \ Hang Seng	Bullish	Neutral	Bearish
Bullish	Better of (Call on Nikkei 225, Call on Hang Seng)	Call on Nikkei 225	Better of (Call on Nikkei 225, Put on Hang Seng) or Spread Option (Nikkei 225-Hang Seng)
Neutral	Call on Hang Seng	---	Put on Hang Seng
Bearish	Better of (Put on Nikkei 225, Call on Hang Seng) or Spread Option (Hang Seng-Nikkei 225)	Put on Nikkei 225	Better of (Put on Nikkei 225, Put on Hang Seng)

Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 71. Performance Option Strategy Payoffs

Nikkei 225 (T) \ Hang Seng (H)	Bullish	Neutral	Bearish
Bullish	$100\times \max\left(0,\frac{T}{To}-1,\frac{H}{Ho}-1\right)$	$100\times \max\left(0,\frac{T}{To}-1\right)$	$100\times \max\left(0,\frac{T}{To}-1,\ 1-\frac{H}{Ho}\right)$ or $100\times \max\left(0,\frac{T}{To}-\frac{H}{Ho}\right)$
Neutral	$100\times \max\left(0,\frac{H}{Ho}-1\right)$	---	$100\times \max\left(0,\ 1-\frac{H}{Ho}\right)$
Bearish	$100\times \max\left(0,\ 1-\frac{T}{To},\frac{H}{Ho}-1\right)$ or $100\times \max\left(0,\frac{H}{Ho}-\frac{T}{To}\right)$	$100\times \max\left(0,\ 1-\frac{T}{To}\right)$	$100\times \max\left(0,\ 1-\frac{T}{To},\ 1-\frac{H}{Ho}\right)$

Source: Smith Barney Inc./Salomon Brothers Inc.

C. Volatility Conditional Options

The options in this final category are designed to modify the effect of the underlying volatility on the option price. These options include **Asian options**, **lookback options**, **compound options,** and **chooser options**.

1. Asian Options

An **Asian** or **average price** option is an option whose payoff is a function of the average price of the underlying asset during all or a portion of the option lifetime. The averaging method and the sampling frequency are also specified in the contract. Specifically, the payoff of an Asian call at expiration is the greater of zero or the difference between this average price and the strike price. The payoff of an Asian put is the greater of zero or the difference between the strike price and the average price.

A closely related structure is the **average strike** option. The payoff of an average strike call is the greater of zero or the difference between the price of the underlying at expiration and the average price, and similarly for an average strike put. So an average strike call provides an investor with the opportunity of *buying* a highly volatile stock for *no more than* the average price. Likewise, an average strike put provides an investor with the opportunity of *selling* a highly volatile stock for *no less than* the average price.

The average price of a stock over the lifetime of the option is much less uncertain than the price on the day of expiration. Therefore, the volatility of the average price is much less than that of the price itself, so the price of an Asian option is less than its standard counterpart.

2. Lookback Options

A **lookback** call (put) option is an option whose strike price is set at expiration to the lowest (highest) price reached by the underlying stock during all or part of the option's lifetime. So the final payoff of a lookback call is the difference between the stock price at expiration and the lowest price reached by the stock during the option period. Likewise, the final payoff of a lookback put is the difference between the highest price reached by the stock during the option period and the stock price at expiration. Thus, the holder of a lookback call can buy the underlying stock in the future at the lowest realized price. Similarly, the holder of a lookback put can sell the underlying stock in the future at the highest realized price.

Lookback options are more expensive than standard options with the same features because they are guaranteed to expire ITM unless the underlying stock price at expiration happens to be the high or low price of the option period. A lookback is actually equivalent to a series of barrier options with each barrier set to the current high or low stock price. Each time the barrier is reached the existing option is knocked-out and a new one is knocked-in at the new high or low. The lookback price is then a function of the sum of these barrier option prices.

Lookback options are appropriate for investors who have conflicting short and long term outlooks for a stock or a portfolio. For example, an investor who believes that the market will fall before it begins a long term upward trend can purchase a lookback call on the S&P 500 to insure that he or she buys at the lowest possible price before the bull market begins. Likewise, an investor who believes that the market will rise before it begins a long term downward trend can purchase a lookback put on the S&P 500 to insure that he or she sells at the highest possible price after the bear market is over.

3. Compound Options

A **compound option** is an option to buy or sell another option. There are four basic types of compound options: a call on a call, a call on a put, a put on a call, and a put on a put. So, for example, a call on a call gives the holder the right to buy a second call option for strike price K_1 at some later time t_1. If the holder exercises the compound option, then he or she takes delivery of the second call which, in turn, gives the holder the right to buy an underlying asset for another strike price, K_2, at a still later time, t_2.

The price of a compound option is usually less than the price of a standard option with the same maturity. However, the price of the compound option plus the price of the underlying option may total more than the price of a standard call or put that is purchased when the compound option begins. However, a compound option has two advantages over a simple option: (1) If volatility decreases, the investor can avoid the full price of a simple option by letting the compound option expire worthless; and (2) if volatility increases, the investor can lock in the price of the underlying option that incorporates a lower volatility than actually exists in the market.

Consider a cautious investor who is bullish on the market but who is also concerned about a possible market decline. He or she could purchase a standard S&P 500 ATM index put option for roughly 2% to 3% of the index value. Alternatively, the investor could purchase a call option on the same S&P 500 index put option for a lower price. If the market is up at expiration, then the value of the underlying put decreases and the call expires worthless. However, the more expensive standard put would also have expired worthless so the investor has lost less with the compound option. If the market is down at expiration, then the value of the underlying put increases and the call expires ITM. The investor exercises, buys the put for the call strike, and receives the desired protection.

4. Chooser Options

An option related to the compound option is the **chooser** or **as-you-like-it option**. A chooser is an option that gives the holder the right to declare it either a standard call or a standard put on a specified date in the future. If a future event can have one of only two possible outcomes, and if either outcome is likely to move the market, then a chooser option allows an investor to profit from the event without having to correctly predict the outcome.

For example, assume a U.S. investor believes that the stock market will rise or fall significantly depending upon the outcome of the presidential election in three months, but the investor is uncertain of whom the winner will be. To profit from the election of either candidate, the investor buys a chooser option on the S&P 500 that is struck at the current index level and that expires two months after the choice date which is the day after the election. On the choice date the investor then declares the option a call if the bullish candidate wins or a put if the bearish candidate wins.

Bibliography

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