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Option Strategies

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OPTION STRATEGIES

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To
my parents
Savitri Parameswaran
and
Late A.S. Parameswaran

PREFACE

Options contracts have been steadily gaining in popularity since they were introduced by BSE and NSE in 2001. They have subsequently become indispensable tools from the standpoint of hedging and speculative trading strategies. This is the seventh book in the *McGraw-Hill Professional: Securities Markets Series.* The book is devoted to the various investment strategies that can be undertaken with the help of call and put options. Market participants would find this volume to be an invaluable source of information for the mechanics of implementing hedging and speculative trading strategies, and the associated payoffs and profits. Each strategy has been diagrammatically illustrated.

The book covers the following issues:

- Long Puts
- Short Calls
- Short Puts
- Covered Calls
- Protective Puts
- Bull Spreads
- Bear Spreads
- Butterfly Spreads
- Condors
- Straddles
- Strangles

- Strips
- Straps
- Box Spreads

Each volume in this series is self-contained and the series should serve as valuable study material for a course on Securities Markets. The manuscripts have been used at business schools as well as for corporate training programmes, and consequently are a blend of academic rigour and practical insights. Students of Finance, and market professionals, in particular those in the BFSI space of information technology, should find these books to be a lucid and concise resource, for developing a strong foundation in the field.

Sunil K. Parameswaran

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Finally, I wish to thank my mother for all her help and moral support.

SUNIL K. PARAMESWARAN

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CHAPTER

Option Strategies and Profit Diagrams

Introduction

In this book, we will analyze various trading strategies that can be set up using call options, put options, and combinations of the two. For each strategy we will compute the payoff and profit for various scenarios at the expiration date of the options. The corresponding breakeven price(s) will be computed, and the profit profile will be graphically illustrated.

Notation

We will use the following symbols to denote the corresponding variables.

- $S_{T^*} \equiv$ breakeven price
- $S_{T^{**}} \equiv$ second breakeven price if there is more than one.

- $C_t \equiv$ call option premium at time 't' for an option expiring at time ' T'.
- $P_t \equiv$ put option premium at time 't' for an option expiring at time ' T'.
- $r \equiv$ riskless rate of interest per annum
- $X \equiv$ exercise price of the option
- $\pi_{\min} \equiv$ maximum loss.
- $\pi_{\max} \equiv$ maximum profit.

In all the graphs, the terminal stock price S_T will be plotted along the X axis, and the profit from the strategy, π will be depicted along the Y axis.

Long Call

Buying a call option is a popular strategy for bullish investors. Consider a call option with an exercise price of X, and a premium of C_t. If the stock price at expiration, $S_T \leq X$, the option will expire worthless and the investor will lose the entire premium. So for the price range, $0 \leq S_T \leq X$, $\pi = -C_t$, where π denotes the profit from the strategy. As the terminal stock price rises above X, for every dollar increase in the price, the investor's profit will go up by one dollar. Therefore, for the price range $S_T > X$, $\pi = S_T - X - C_t$. The breakeven price S_{T^*} is equal to $X + C_t$. The maximum loss, $\pi_{\min}$, is obviously the premium paid at the outset. The maximum profit on the other hand is unlimited because the stock price has no upper bound.

Example 1

Consider a stock whose current price is \$ 100. The riskless rate of interest is 10% per annum, and the volatility is

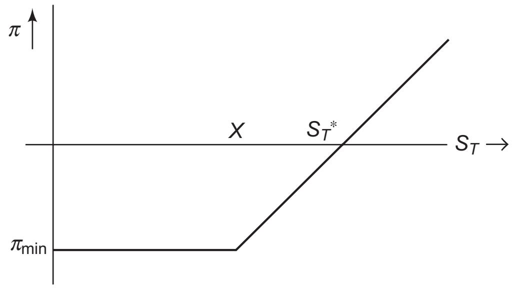

Fig. 1.1

30% per annum. The premium for an option with an exercise price of $ 100, and a time to expiration of six months, is $ 10.91.[1]

If the stock price at expiration is less than $ 100, the option will expire out of the money. The loss will be equal to the premium paid for the option which is $ 10.91. As the stock price at expiration rises above $ 100, then for every dollar increase in the stock price, the profit from the call increases by one dollar. The breakeven stock price is $X + C_t = 100 + 10.91 =$ $ 110.91. The maximum profit is obviously unlimited.

Let us list the values of the call for stock price values ranging from $ 90 to $ 110 (in intervals of $ 2.50), for times to expiration ranging from 0.5 years to 0.1 years (in intervals of 0.1 years). The last column in Table 1.1 gives the percentage loss over the life of the option, if the stock price were to remain constant, and the options are acquired with 0.5 years to maturity, and held till expiration. For instance, if the option is acquired when the stock price is $ 90, and there are 0.5 years to expiration, a premium of $ 5.52 would have to be paid. If held till expiration, the

[1] We have used the Black-Scholes formula to compute the option prices.

option will expire out of the money if the stock price remains constant. Thus the loss for an investor is 100% of the premium paid. On the contrary, if the option is acquired when the initial stock price is \$ 110 and there are 0.50 years to maturity, a premium of \$ 18.05 would have to be paid. At expiration the option will expire in the money, and the payoff will be equal to its intrinsic value of \$ 10. The loss for the investor is

$$\frac{10 - 18.05}{18.05} \equiv -44.60\%$$

The breakeven stock prices corresponding to options with different values for the initial stock price, as a function of the times to expiration are as depicted in Table 1.2. Let us analyze a few of the entries in the first row of the table. If the initial stock price is \$ 90, the premium for an option with 0.50 years to expiration is \$ 5.52. After 0.10 years, that is with 0.40 years to expiration, the stock price would have to be \$ 92.60 if the option is to have a premium of \$ 5.52. Thus the breakeven stock price, corresponding to the original option is \$ 92.60 when there are 0.40 years left to expiration. Similarly, after 0.20 years, that is when there are 0.30 years left to expiration, the stock price will have to be at \$ 95.43 if an option with 0.30 years to maturity is to have a price of \$ 5.52. Consequently the breakeven stock price corresponding to the original option is \$ 95.43 when there are 0.30 years to expiration. The remaining entries in the table can be similarly interpreted.

As can be seen from Table 1.2, irrespective of the stock price at which the position is initiated, the breakeven price is higher than the stock price at inception. Thus the strategy is truly bullish in nature, in the sense that the investor can make money, only if the price of the stock were to rise.

Table 1.1

Call Premia for Different Stock Prices and Expiration Times

Stock Price	*Time in Years*						*% age loss in 0.5 years*
	0.50	0.40	0.30	0.20	0.10	0.00	
			Call Premia				
90.00	5.52	4.40	3.23	2.0	0.74	0.00	–100%
92.50	6.68	5.48	4.20	2.80	1.26	0.00	–100%
95.00	7.97	6.69	5.32	3.79	2.01	0.00	–100%
97.50	9.38	8.05	6.60	4.97	3.01	0.00	–100%
100.00	10.91	9.53	8.04	6.34	4.28	0.00	–100%
102.50	12.55	11.15	9.62	7.90	5.81	2.50	–80.08%
105.00	14.29	12.87	11.34	9.62	7.57	5.00	–65.01%
107.50	16.12	14.71	13.18	11.49	9.54	7.50	–53.47%
110.00	18.05	16.64	15.13	13.48	11.66	10.00	–44.60%

Table 1.2

Breakeven Stock Prices Corresponding to Options with Different Values for the Initial Stock Price as a Function of the Time to Expiration

Initial Stock	*Time in Years*				
Price	0.40	0.30	0.20	0.10	0.00
	Breakeven Stock Prices				
90.00	92.60	95.43	98.54	102.06	105.52
92.50	94.98	97.66	100.57	103.78	106.68
95.00	97.38	99.90	102.62	105.53	107.97
97.50	99.76	102.15	104.67	107.32	109.38
100.00	102.16	104.39	106.76	109.13	110.91
102.50	104.55	106.67	108.86	111.01	112.55
105.00	106.95	108.95	110.98	112.92	114.29
107.50	109.35	111.23	113.11	114.88	116.12
110.00	111.77	113.54	115.29	116.90	118.05

The price which the stock must attain in order for the position to breakeven depends on whether the position is held to expiration, or is offset prior to that. For instance assume that the call is purchased when the stock price is $ 100 and the time to expiration is 0.50 years. The breakeven stock price if the position is held to expiration is $ 110.91. However if we sell the call when the time to expiration is 0.40 years, the breakeven stock price is $ 102.16. Thus the corresponding price at expiration is the highest value that the stock must attain if the position is to breakeven.

The more out of the money the option, at the time of inception of the strategy, the more bullish is the strategy. For instance, the option premium when the stock price is $ 90, and the time to expiration is 0.50 years, is $ 5.52. The breakeven stock price for this option at expiration is

$ 105.52, which is $ 15.52 above the prevailing stock price. However, if the stock price at the outset is $ 105, the breakeven stock price at expiration is $ 114.29, which is only $ 9.29 above the prevailing stock price.

A more bullish strategy is obviously riskier and should yield better returns if the investor's price expectations are met. Take the case of the call when the stock price is $ 95 and the time to expiration is 0.5 years. If the price of the call were to double when the time to expiration is 0.4 years, the stock price would have to rise to $ 109.10. On the other hand, a call acquired when the stock price is $ 105 and the time to expiration is 0.5 years, would require the stock price to rise to $ 123.80, if it were to double in value over the next 0.10 years.

Out of the money calls also experience a greater premium decay with the passage of time. Consider a call with $X=$ $ 100 when the prevailing stock price is $ 90. The premium when there are six months left to expiration is $ 5.52. If the stock price were to remain constant, the premium when there are 0.1 years left to expiration is $ 0.74. The percentage decline is:

$$\frac{0.74-5.52}{5.52} \equiv -87\%$$

Now take the case of a call with $X=$ $ 100, when the stock price is $ 105. The premium decay when the time to expiration declines from 0.50 years to 0.10 years is:

$$\frac{7.57-14.29}{14.29} \equiv -47\%$$

Speculating with Calls

Andrew Smith is bullish about IBM and wants to speculate using call options. Options with an exercise price of $ 100 and three months to expiration are available at a premium of \$ 8. The current stock price is \$ 100. If we assume that Andrew goes long in one contract, his total investment is

$$8 \times 100 = \$\ 800$$

Assume that at expiration, the price of IBM is \$ 125. Since the option is in the money, Andrew will exercise. His profit will be

$$(125 - 100) \times 100 - 800 = \$\ 1,700$$

The 90/10 Strategy

This strategy entails an investment of 10% of the funds at an investor's disposal in call options, and the balance 90% in a money market instrument such as a T-bill.

Assume that Andrew has \$ 8,000 available with him for investment. He decides to buy call options with an exercise price of \$ 100, and with three months to expiration, by paying a premium of \$ 800, which is 10% of his wealth. He then invests the balance of \$ 7,200 in T-bills, which we will assume yield 8% per annum.

The return from the T-bills over three months is

$$7{,}200 \times 0.08 \times 0.25 = \$\ 144$$

The effective cost of the options contract is therefore

$$800 - 144 = \$\ 656$$

If the stock price at expiration is less than \$ 100, Andrew will incur a loss of \$ 656. This is his maximum possible loss. If the terminal stock price is between \$ 100 and \$ 106.56, he will incur a loss which is given by

$$-656 \le \pi \le 0$$

Thus, the breakeven stock price is \$ 106.56. For values of the terminal stock price in excess of \$ 106.56, Andrew will make a profit. His maximum profit is unbounded.

Buying Calls to Lock in a Share Price

IBM is currently trading at \$ 100 per share. Andrew would like to acquire 100 shares but does not have the required funds. He is however confident that he will have adequate funds in three months time. Three month options on IBM are available at a premium of \$ 8 per share and the exercise price is \$ 100. Assume that Andrew goes long in one contract.

If the stock price after three months is \$ 125, the options can be exercised and 100 shares of IBM can be acquired at a cost of

$$100 \times 100 + 800 = \$\ 10{,}800$$

or \$ 108 per share. The cost of the shares would have been \$ 125 each, if Andrew had not taken a position in the options.

Long Put

Buying a put option is a strategy for bearish investors. Consider a put option with an exercise price of X, and a premium of P_t. If the stock price at expiration, $S_T \geq X$, the option will expire worthless and the investor will lose the entire premium. So for the price range $S_T \geq X$, $\pi = -P_{t^*}$. As the terminal stock price declines below X, for every dollar decline in the price, the investor's profit will go up by one dollar. Therefore, for the price range $0 \leq S_T \leq X$, $\pi = X - S_T - P_t$. The breakeven price S_{T^*} is equal to $X - P_t$.

The maximum loss, π_{min} is obviously equal to the premium paid at the outset, which is P_t. The maximum profit, π_{max}, is equal to $X - P_t$. This is because due to the limited liability feature of stocks, the lowest possible share price is zero.

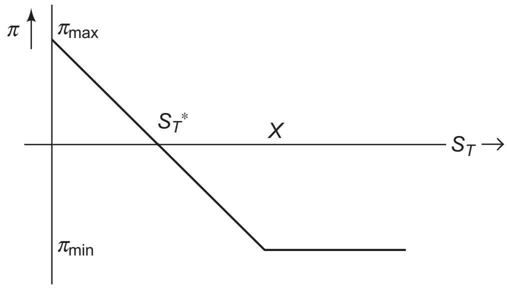

Fig. 1.2

Example 2

Consider a stock whose current price is \$ 100. The riskless rate of interest is 10% per annum, and the volatility is 30% per annum. The premium for a put option with an exercise price of \$ 100, and a time to expiration of six months, is \$ 6.03.

If the stock price at expiration is greater than \$ 100, the option will expire out of the money. The loss will be equal to the premium paid for the option which is \$ 6.03. As the stock price at expiration falls below \$ 100, then for every dollar decrease in the stock price, the profit from the put increases by one dollar. The breakeven stock price is

$$X - P_t = 100 - 6.03 = \$\ 93.97$$

The maximum profit is equal to \$ 93.97, which corresponds to a terminal stock price of zero.

Let us list the values of the put for stock price values ranging from \$ 90 to \$ 110 (in intervals of \$ 2.50), for times to expiration ranging from 0.5 years to 0.1 years (in intervals of 0.1 years). The last column in Table 1.3 gives the percentage loss over the life of the option, if the stock price were to remain constant, and the options are acquired with 0.50 years to expiration, and held until maturity.

The more out of the money the option, at the time of inception of the strategy, the more bearish is the strategy. For instance, if the put is acquired when the prevailing stock price is \$ 90, the premium is \$ 10.64. The corresponding breakeven point is 100 – 10.64 = \$ 89.36. Thus the stock would have to decline by \$ 0.64 in order for the position to breakeven. On the other hand, if one were to acquire the put when the prevailing stock price is \$ 107.50, the premium will be only \$ 3.75, and the corresponding breakeven price is 96.25. In this case the stock would have to decline by \$ 11.25 in order for the position to breakeven.

Speculating with Puts

Mike Faye is bearish about IBM and is confident that the stock will decline in value over the next three months. One alternative is for him to short sell shares of IBM. But this strategy can give rise to unlimited losses. This is because, he will have to acquire the stock eventually to cover his short position, and the stock price has no upper bound. Besides, to establish a short position, he needs to set up a margin account, and margin calls may compel him to cover the position prematurely despite the fact that the position may still have profit potential. A long put on the other hand, allows him to speculate while restricting his maximum potential loss to the premium paid for the options.

Table 1.3

Put Premia for Different Stock Prices and Expiration Times

Stock Price	*Time in Years*						*% age Loss in 0.5 years*
	0.50	0.40	0.30	0.20	0.10	0.00	
			Put Premia				
90.00	10.64	10.48	10.28	10.02	9.74	10.00	–6.02%
92.50	9.30	9.06	8.74	8.32	7.77	7.50	–24.00%
95.00	8.09	7.77	7.36	6.81	6.01	5.00	–38.20%
97.50	7.00	6.63	6.14	5.49	4.52	2.50	–64.29%
100.00	6.03	5.61	5.08	4.36	3.29	0.00	–100%
102.50	5.17	4.72	4.16	3.42	2.32	0.00	–100%
105.00	4.41	3.95	3.38	2.64	1.58	0.00	–100%
107.50	3.75	3.29	2.72	2.01	1.04	0.00	–100%
110.00	3.17	2.72	2.17	1.50	0.67	0.00	–100%

Assume that the current stock price is \$ 100, and that put options with an exercise price of \$ 100 and three months to expiration, are available at a premium of \$ 4.75 per share. If the stock price at expiration were to be \$ 80 per share, Mike would exercise the options. His profit will be

$$(100 - 80) \times 100 - 4.75 \times 100 = \$\ 1{,}525$$

However, if the terminal stock price were to be \$ 120, Mike would refrain from exercising the options, and his loss would be the premium paid at the outset, which is \$ 475.

Buying Calls to Hedge a Short Sale

This strategy entails the purchase of one call option for every share that is sold short.

Profit from the short position in the stock $= S_t - S_T$. Profit from the call $= \text{Max}[0, S_T - X] - C_t$. The total profit is given by $\pi = S_t - S_T + \text{Max}\ [0, S_T - X] - C_t$.

If $S_T \leq X, \pi = S_t - S_T - C_t$. For every dollar that the stock price declines below X, the investor gains a dollar. The breakeven point S_{T^*} is $= S_t - C_t$. The maximum profit π_{max} is $= S_t - C_t$.

If $S_T \geq X, \pi = S_t - X - C_t$, which is the maximum loss. The profit diagram may be depicted as follows.

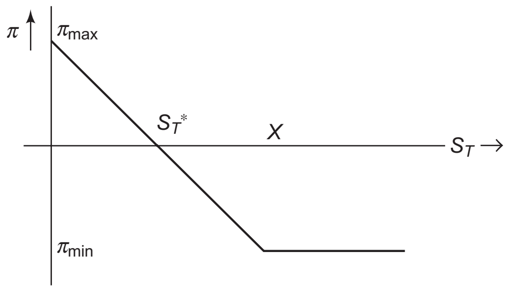

Fig. 1.3

The payoff looks like the one for a long put. This is not surprising, because from put-call parity,

$$P_t - \frac{X}{(1+r)^{T-t}} = C_t - S_t$$

Thus buying a call, and shorting a share, is equivalent to buying a put and borrowing.

Example 3

Andrew has short sold 100 shares of IBM at a price of \$ 100. Quite obviously he is expecting the shares to decline in value. However, there is always a possibility that the stock may rise in value, and lead to a loss when Andrew eventually covers his short position. One way to cap the loss is to invest in call options.

Assume that call options with an exercise price of \$ 100 and three months to expiration are available at a premium of \$ 8, and that Andrew buys one contract. If the share price after three months is \$ 120, it would cost Andrew \$ 10,000 to acquire 100 shares and cover his position. After factoring in the cost of the options, his total cost will be \$ 10,800, which amounts to \$ 108 per share. The loss from the strategy is

$$10{,}000 - 10{,}800 = \$\ (800)$$

If the calls had not been acquired the loss would have been

$$(100 - 120) \times 100 = \$\ (2{,}000)$$

The Protective Put

The strategy entails buying the stock and then buying a put option on it, to gain downside protection. $\pi = S_T - S_t - P_t + \text{Max}[0, X - S_T]$. If $S_T \geq X$, $\pi = S_T - S_t - P_t$, while if S_T is $\leq X$, $\pi = X - S_t - P_t$. The maximum profit is unlimited. The maximum loss π_{max} is $X - S_t - P_t$. The breakeven price $= S_t + P_t$.

The profit diagram may be depicted as follows.

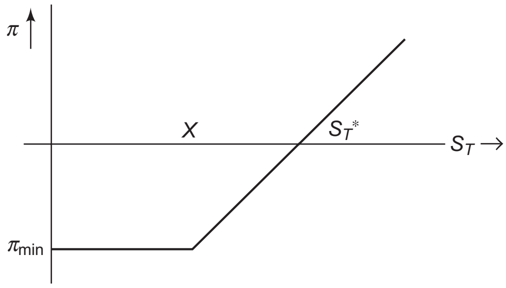

Fig. 1.4

For obvious reasons, the profit diagram resembles that of a long call.

In this case the put acts like an insurance policy. By buying the option with an exercise price of X, the investor ensures that he will not have to sell the stock at a lower price. The higher the exercise price, the greater will be the floor for the stock price. However, the higher the exercise price, the greater will be the option premium, and consequently the higher will be the breakeven point. Thus, an in the money put offers greater downside protection, but requires a larger increase in the stock price for the strategy to turn profitable.

Example 4

Larry King owns 100 shares of IBM that are currently trading at \$ 100. Put options with six months to expiration are available. An option with an exercise price of \$ 90 is available at a premium of \$ 2.65, while an option with an exercise price of \$ 110 is available for \$ 11.16.

If Larry acquires a contract with $X = \$\ 90$, his maximum loss will be

$$90 - 100 - 2.65 = \$\ (12.65)$$

and the breakeven stock price will be \$ 102.65. On the contrary if Larry were to acquire a contract with $X = \$\ 110$, his maximum loss will be

$$110 - 100 - 11.16 = \$\ (1.16)$$

However the breakeven in this case will be \$ 111.16.

Thus the greater downside protection comes with a cost. And the cost is that the investor will have to give up more of the upside gains, if the stock were to go up in value.

Writing a Naked Call

This strategy requires the investor to sell call options without taking a position in the underlying stock. Consider a call with an exercise price of X and a premium of C_t. If the stock price at expiration, $S_T \leq X$, the call will expire worthless and the profit for the call writer will be the premium received at the outset. So if $0 \leq S_T \leq X$, $\pi = C_t$. As the terminal stock price rises above X, for every dollar increase in the stock price, the profit will decline by a dollar. Therefore, for the price range $S_T \geq X$, $\pi = -(S_T - X) + C_t$. The breakeven price is, S_{T^*} equal to $X + C_t$.

The maximum profit is the premium received at the outset. The maximum loss is unbounded.

The profit diagram may be depicted as follows.

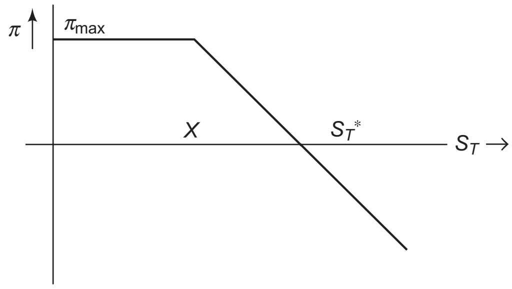

Fig. 1.5

Example 5

Consider a stock which is currently trading at \$ 100. The riskless rate of interest is 10% per annum, and the volatility is 30% per annum. The premium for a call option with an exercise price of \$ 100, and three months to expiration, is \$ 7.22.

If the stock price at expiration is less than the exercise price of \$ 100, the option will expire out of the money, and the profit for the writer is the premium received at the outset which is $7.22 \times 100 = \$\,722$ per contract. This represents the maximum profit for the writer. As the stock price rises above \$ 100, for every dollar increase in the price, the profit declines by one dollar. The breakeven stock price is $X + C_t = 100 + 7.22 = \$\,107.22$. The maximum loss is unlimited.

In the Money versus Out of the Money Calls

Consider the following data for call options with various exercise prices. The current stock price is \$ 100.

Table 1.4

Call Options with Varying Exercise Prices

Exercise Price	*Premium*	*Breakeven Price*
$ 90	$ 17.03	$ 107.03
$ 100	$ 10.91	$ 110.91
$ 110	$ 6.52	$ 116.52

The at the money call yields the maximum profit if the terminal stock price, S_T is equal to $ 100. The option also yields a positive profit in the range, $100 \leq S_T \leq 110.91$, since the breakeven price is $ 110.91. The out of the money option has the lowest premium, which is $ 6.52 in this case. The profit for the call writer is less, but he gets greater protection against a rising stock price, since the terminal stock price must exceed $ 110 in order for exercise to be a worthwhile proposition for the buyer. The in the money option has the highest premium. If the stock price remains at $ 100, the profit from the position is

$$-(100 - 90) + 17.03 = \$\ 7.03$$

In order for the writer to realize the maximum profit from this option, the stock price must decline from its current level of $ 100 to $ 90 or below. Thus, the sale of an in the money option represents a more bearish strategy than the sale of an at the money or out of the money option.

Writing a Put

Consider a put option with an exercise price of X, and a premium of P_t. If the stock price at expiration, $S_T \geq X$, the option will expire worthless, and the profit for the writer will be P_t. So in the price range, $S_T \geq X$, $\pi_{max} = P_t$. As the terminal stock price declines below X, the writer's profit will decline dollar for dollar. Thus, for the price range, $0 \leq S_T \leq X$, $\pi = -(X - S_T) + P_t$. The breakeven price S_{T^*} is equal to $X - P_t$. The maximum profit is obviously the premium that is received at the outset. The magnitude of the maximum loss is $X - P_t$, because the stock price has a lower bound of zero.

The profit diagram may be depicted as follows.

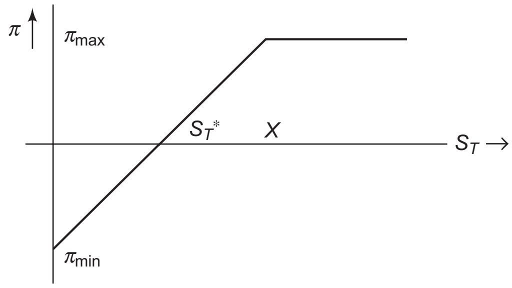

Fig. 1.6

Example 6

Consider a stock which is currently trading at \$ 100. The riskless rate of interest is 10% per annum, and the volatility is 30% per annum. The premium for a put option with an exercise price of \$ 100, and three months to expiration, is \$ 4.75.

If the stock price at expiration is greater than the exercise price of \$ 100, the option will expire out of the money, and the profit for the writer is the premium received at the outset which is $4.75 \times 100 = \$ 475$ per contract. This represents the maximum profit for the writer. As the stock price declines below \$ 100, for every dollar decrease in the price, the profit declines by one dollar. The breakeven stock price is $X - P_t = 100 - 4.75 = \$\,95.25$. The maximum loss is \$ 95.25, which will arise if the stock price were to attain a value of zero.

Short Put Combined with Short Stock

This strategy entails the sale of a put option for every share that is sold short. The profit from the short stock is $S_t - S_T$, while that from the put is $P_t - \text{Max}[0, X - S_T]$.

Thus the total profit from the strategy is

$$\pi = P_t - \text{Max}\,[0, X - S_T] + S_t - S_T$$

If $S_T \leq X$, $\pi = S_t + P_t - X$, whereas if $S_T > X$, $\pi = P_t + S_t - S_T$

The maximum loss is unlimited because the stock has no upper bound. The breakeven price, S_{T^*}, is $P_t + S_t$. The maximum profit is equal to $S_t + P_t - X$.

The payoff diagram may be depicted as follows.

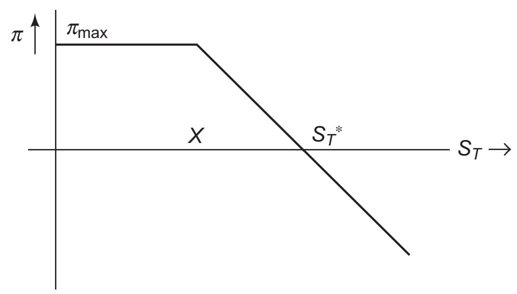

Fig. 1.7

Example 7

Bob Harris has sold short 100 shares of IBM at a price of \$ 100. Put options with three months to expiration, and an exercise price of \$ 100 are available at a premium of

$ 10.16 per share. Let us consider the terminal profit from the investment if Bob writes one put contract.

If the terminal stock price exceeds $ 100, the puts will not be exercised. Bob's profit from the short stock position will be $(100 - S_T) \times 100$. After factoring in the premium for the options, the overall profit will be

$$\pi = (100 - S_T) \times 100 + 10.16 \times 100$$

The breakeven stock price is 100 + 10.16 = $ 110.16. The maximum loss is unbounded. If the terminal stock price, S_T, is less than $ 100, the puts will be exercised. The profit from the strategy will be

$$\pi = (10.16 + 100 - 100) \times 100 = \$\ 1,016$$

This represents the maximum profit.

Writing a Covered Call

This strategy entails the sale of a call option for every share that is owned by the investor. There are two possibilities. The calls can be sold at the time of acquisition of the shares. Or else, the purchase of the shares can precede the sale of the options. The first strategy is called *'Buy-writing'*, while the second is termed as *'Over-writing'*.

The profit from the long stock is $S_T - S_t$, while that from the call is $C_t - \text{Max}[0, S_T - X]$. Thus the total profit from the strategy is

$$S_T - S_t + C_t - \text{Max}\,[0, S_T - X]$$

If $S_T \geq X$, $\pi = X - S_t + C_t$, whereas if $S_T \leq X$, $\pi = S_T - S_t + C_t$

As the terminal stock price goes below X, the profit declines dollar for dollar. The maximum loss occurs when the terminal stock price is zero, and is equal to $C_t - S_t$. The breakeven price is $S_t - C_t$. The maximum profit is equal to $X - S_t + C_t$.

The profit diagram may be depicted as follows.

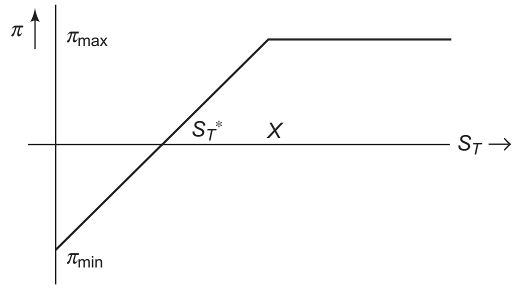

Fig. 1.8

Notice that the profit diagram looks like the one for a put writer.

Example 8

Maureen Smith owns 100 shares of IBM which she acquired at a price of \$ 100. She simultaneously sold a call options contract with an exercise price of \$ 100, and three months to expiration, for a premium of \$ 7.22 per share. The profit from the stock position is $S_T - 100$, while that from the call is $7.22 - \text{Max}[0, S_T - 100]$. If the terminal stock price is below \$ 100, the counterparty will not exercise the calls. The profit for Maureen in this scenario will therefore be

$$\pi = (S_T - 100) \times 100 + 7.22 \times 100$$

The range for the profit on a per share basis is

$$-92.78 \leq \pi \leq 7.22$$

If S_T were to be greater than \$ 100, the share will be called away, and the profit for Maureen will be capped at \$ 7.22

per share. If Maureen had not sold the calls, the profit would have been $S_T - 100$. If the stock price were to exceed \$ 107.22 or $X + C_t$, she will regret the fact that she had sold the calls. Thus $X + C_t$ is called the *'point of regret'*.

Consider the maximum profit for the strategy which is $X - S_t + C_t$. However high the stock price may rise, this represents the maximum profit from the strategy. Thus, in exchange for the option premium, the call writer accepts an upper limit on the profit. The option premium however serves to reduce the magnitude of the loss if the stock price were to decline, as compared to a standalone long stock position.

The profit from the position for various values of the terminal stock price is as depicted below.

Table 1.5

Profit from the Covered Call for Various Values of the Terminal Stock Price

Stock Price	*Payoff From Call*	*Profit/Loss From Call*	*Profit/Loss From Stock*	*Total Profit/Loss*
80	0	722	(2,000)	(1,278)
85	0	722	(1,500)	(778)
90	0	722	(1,000)	(278)
95	0	722	(500)	(222)
100	0	722	0	722
101	(100)	622	100	722
105	(500)	222	500	722
107.22	(722)	0	722	722
110	(1,000)	(278)	1,000	722
115	(1,500)	(778)	1,500	722
120	(2,000)	(1,278)	2,000	722

As can be seen, below a stock price of $ 100, the loss from the stock is reduced by $ 722 due to the receipt of the premium from the call. As the call goes into the money, the stock is called away and the total profit is $ 722, which is the premium received from the call. The point of regret is $ 107.22. Beyond this stock price the investor will regret the fact that he wrote the call, since he will be unable to realize the profit from the stock.

In the Money, at the Money, and Out of the Money

Assume that the initial stock price is $ 100. Consider three call options with three months to expiration, and exercise prices of $ 90, $ 100, and $ 110 respectively. The corresponding premia are $ 13.71, $ 7.22, and $ 3.22. Let us consider covered call strategies with each of these contracts.

Table 1.6

Option Premia for
Varying Degrees of Moneyness

Exercise Price	*Maximum Profit*
$ 90	$ 3.71
$ 100	$ 7.22
$ 110	$ 13.22

An at the money option would be favoured by a neutral investor, because the maximum return is obtained if the stock price were to remain at its initial level. A strategy with an out of the money option, is bullish by design, because the maximum profit is realized if the stock price rises above its current level to reach a value equal to the exercise price.

In the above illustration, the stock price must rise from a current level of $ 100 to reach the exercise price of $ 110, in order for the investor to obtain the maximum profit. The total profit for 100 shares is $ 1,322, if the stock price rises to $ 110. Out of this $ 1,000 arises from the stock component, and $ 322 from the option component. While the maximum profit from the out of the money call is the greatest, there is a trade off if the stock price were to decline. This is because, the out of the money call has the smallest premium, and consequently provides the least protection if the share were to fall in value. In our illustration, the at the money call provides a protection of $ 7.22 per share in a declining market, whereas the out of the money call gives a protection of only $ 3.22 per share.

Spreads

A spread is a strategy that involves taking a position in two or more options of the same type. That is all the options must be calls, or all of them should be puts.

Vertical Spreads

To create a vertical spread the investor must buy an option with one exercise price, and sell another with a different exercise price. Both the options must have the same time to expiration. Vertical spreads are also known as *Strike* or *Money* or *Price* spreads.

Horizontal Spreads

To create this kind of a spread, the investor must buy an option with a given exercise price and expiration month, and sell another option with the same exercise price, but with a different expiration month. Horizontal spreads are also known as *Time* or *Calendar* spreads.

Diagonal Spreads

These are strategies where you buy an option with a given exercise price and time to maturity, and sell another option with a different exercise price and time to maturity.

We will focus only on vertical spreads.

Bull Spreads

With Calls

To create a bull spread with calls, the investor has to buy a call option with an exercise price $= X_1$, and sell a call on the same asset with an exercise price $= X_2$, where $X_1 < X_2$. Let $C_{t,1}$ be the premium for the first option, and $C_{t,2}$, the premium for the second. Since $X_1 \leq X_2$, $C_{t,1}$ must be $> C_{t,2}$.

The initial cash flow $= -C_{t,1} + C_{t,2}$ which is < 0. Thus a bull spread with calls involves a net investment.

Let us consider the payoff from a bull spread at expiration.

Table 1.7

Payoffs from a Bull Spread With Calls

Terminal Price Range	*Payoff From Long Call*	*Payoff From Short Call*	*Total Payoff*
$S_T < X_1$	0	0	0
$X_1 < S_T < X_2$	$S_T - X_1$	0	$S_T - X_1$
$S_T > X_2$	$S_T - X_1$	$-(S_T - X_2)$	$X_2 - X_1$

To calculate the profit in each scenario, we must subtract the initial investment from the payoff. The maximum payoff is obviously $X_2 - X_1$. The minimum payoff = 0. Thus, the maximum profit is $X_2 - X_1 - C_{t,1} + C_{t,2}$, and the maximum loss is $-C_{t,1} + C_{t,2}$. A bull spread, therefore, limits the upside potential while putting a limit on the downside risk. The breakeven stock price is given by,

$$\pi = S_{T^*} - X_1 - C_{t,1} + C_{t,2} = 0$$

$$\Rightarrow \quad S_T^* = X_1 + C_{t,1} - C_{t,2}$$

The profit diagram may be depicted as follows.

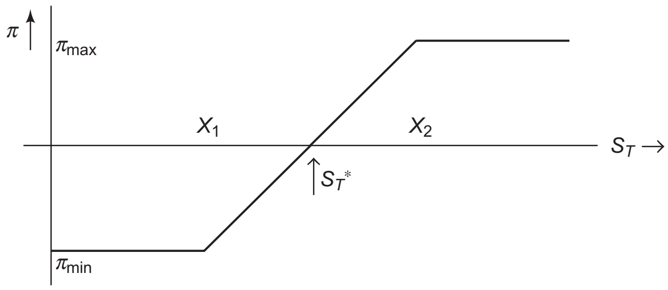

Fig. 1.9

Example 9

Amy Hepburn has bought a call option with an exercise price of \$ 90 at a premium of \$ 13.71, and sold a call option with the same maturity, but with a higher exercise price of \$ 110, for a premium of \$ 3.22. The position obviously represents a bull spread. The initial investment is \$ 13.71 – \$ 3.22 = \$ 10.49. This is also the maximum loss from the strategy. The breakeven point is given by

$$S_T^* - 90 - 10.49 = 0 \quad \Rightarrow \quad S_T^* = 100.49$$

The maximum payoff from the spread is the difference between the two exercise prices, which is \$ 20 in this case.

The maximum profit is $ 20 – $ 10.49 = $ 9.51. The maximum profit is obtained for all values of the terminal stock price equal to or greater than $ 110.

Table 1.8

Profit from the Bull Spread for Various Values of the Terminal Stock Price

Stock Price	*Payoff From Long Call*	*Payoff From Short Call*	*Payoff From The Spread*	*Total Profit/Loss*
80	0	0	0	(1,049)
85	0	0	0	(1,049)
90	0	0	0	(1,049)
95	500	0	500	(549)
100	1,000	0	1,000	(49)
100.49	1,049	0	1,049	0
105	1,500	0	1,500	451
110	2,000	0	2,000	951
115	2,500	(500)	2,000	951
120	3,000	(1,000)	2,000	951

The maximum loss is $ 1,049 which is the net premium paid for the spread. $ 100.49 is the breakeven point. The maximum profit from the spread is $ 951, which is equal to the difference between the two exercise prices, less the net premium paid. That is $ 951 = 100 × (110 – 90 – 10.49).

Bull Spread or Long Call

A long call position limits the investor's loss to the premium that is paid at the outset, without imposing an upper bound on the profit from the strategy. The question naturally arises as to what makes an investor like Amy prefer a bull spread to a long call, considering that the spread can yield only a limited profit.

Let us take Amy's example. If she had bought a call option with $X = \$ 90$, she would have made an investment of \$ 13.71 per share. The bull spread however limits her investment to \$ 10.49 per share, because there is an inflow from the option that is sold. An investor like Amy may be bullish, but may not consider the additional investment to be warranted, considering her expectations from the stock.

With Puts

To create a bull spread with puts, the investor has to buy a put option with an exercise price equal to X_1, and sell a put on the same asset with an exercise price equal to X_2, where $X_1 < X_2$. Let $P_{t,1}$ be the premium for the first option, and $P_{t,2}$ the premium for the second. Since $X_1 < X_2$, $P_{t,1}$ must be less than $P_{t,2}$.

The initial cash flow $= -P_{t,1} + P_{t,2}$ which is greater than zero. Thus a bull spread with puts leads to an inflow at inception.

Let us analyze the payoff from the spread at expiration.

Table 1.9

Payoffs from a Bull Spread with Puts

Terminal Price Range	*Payoff From Long Put*	*Payoff From Short Put*	*Total Payoff*
$S_T < X_1$	$X_1 - S_T$	$-(X_2 - S_T)$	$X_1 - X_2$
$X_1 < S_T < X_2$	0	$-(X_2 - S_T)$	$S_T - X_2$
$S_T > X_2$	0	0	0

To calculate the profit in each scenario, we must add the initial inflow to the payoff. The minimum payoff is obviously $X_1 - X_2$. The maximum payoff is zero. Thus the maximum loss is $X_1 - X_2 - P_{t,1} + P_{t,2}$, and the maximum profit is $-P_{t,1} + P_{t,2}$. As is to be expected, the upside potential is limited, as is the downside risk. The breakeven stock price is given by

$$S_{T^*} - X_2 - P_{t,1} + P_{t,2} = 0$$
$$\Rightarrow \quad S_{T^*} = X_2 + P_{t,1} - P_{t,2}$$

Example 10

Stacey Smith has bought a put option with an exercise price of $ 90 at a premium of $ 1.49, and sold a put option with the same maturity, but with a higher exercise price of $ 110, for a premium of $ 10.51. The initial inflow is $ 10.51 – $ 1.49 = $ 9.02. This represents the maximum profit from the strategy. The breakeven point is given by

$$S_{T^*} - 110 - 1.49 + 10.51 = 0 \Rightarrow S_{T^*} = \$\ 100.98$$

The minimum payoff from the strategy is 90 – 110 = – $ 20. The maximum loss is therefore –20 + 9.02 = –$ 10.98.

Bear Spreads

With Calls

To create a bear spread with calls, the investor has to sell a call option with an exercise price of X_1, and buy a call on the same asset with an exercise price of X_2, where $X_1 < X_2$. Let the respective prices of the options be $C_{t,1}$ and $C_{t,2}$. We know that $C_{t,1} > C_{t,2}$.

The initial cash flow $= - C_{t,2} + C_{t,1}$, which is > 0. Thus a bear spread with calls leads to an inflow at inception.

Let us consider the payoff from the spread at expiration.

Table 1.10

Payoffs from a Bear Spread with Calls

Terminal Price Range	*Payoff From Long Call*	*Payoff From Short Call*	*Total Payoff*
$S_T < X_1$	0	0	0
$X_1 < S_T < X_2$	0	$-(S_T - X_1)$	$X_1 - S_T$
$S_T > X_2$	$S_T - X_2$	$-(S_T - X_1)$	$X_1 - X_2$

The maximum payoff is obviously zero. The minimum payoff is $X_1 - X_2$. Thus, the maximum profit is $C_{t,1} - C_{t,2}$, while the maximum loss is $X_1 - X_2 + C_{t,1} - C_{t,2}$. Thus, just like the bull spread, the bear spread limits the upside potential while putting a limit on the downside risk. The breakeven stock price is given by

$$\pi = X_1 - S_{T^*} + C_{t,1} - C_{t,2} = 0$$

$$\Rightarrow S_{T^*} = X_1 + C_{t,1} - C_{t,2}$$

The profit diagram may be depicted as follows.

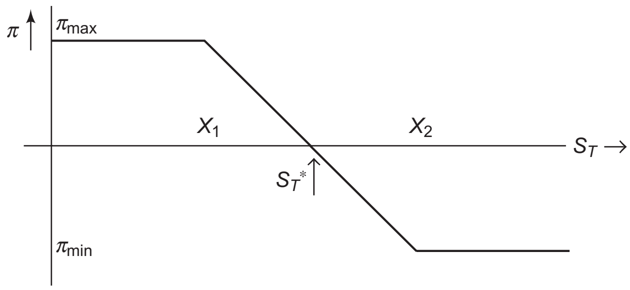

Fig. 1.10

Example 11

Kevin Long has sold a call option with an exercise price of \$ 90 at a premium of \$ 13.71, and bought a call with the same maturity, but with an exercise price of \$ 110, for a premium of \$3.22. The initial cash inflow is \$ 13.71– \$ 3.22 = \$ 10.49. This is also the maximum profit from the strategy. The breakeven point is given by

$$90 - S_{T^*} + 10.49 = 0 \Rightarrow S_{T^*} = \$\,100.49$$

The minimum payoff from the strategy is the difference between the two exercise prices which is –\$ 20 in this case. The maximum loss is therefore \$ 10.49 – \$ 20 = – \$9.51. The maximum loss occurs for all values of the stock price equal to greater than \$ 110.

With Puts

To create a bear spread with puts, the investor has to sell a put option with an exercise price of X_1 and buy a put on the same asset with an exercise price of X_2, where $X_1 < X_2$. Let $P_{t,1}$ be the price of the first option, and $P_{t,2}$ the price of the second. Since $X_1 < X_2$, $P_{t,1} < P_{t,2}$.

The initial cash flow $= -P_{t,2} + P_{t,1}$, which is less than zero. Thus the strategy entails a cash outflow at inception.

Let us analyze the payoff from the spread at expiration.

Table 1.11

Payoffs from a Bear Spread with Puts

Terminal Price Range	*Payoff From Long Put*	*Payoff From Short Put*	*Total Payoff*
$S_T < X_1$	$X_2 - S_T$	$-(X_1 - S_T)$	$X_2 - X_1$
$X_1 < S_T < X_2$	$(X_2 - S_T)$	0	$X_2 - S_T$
$S_T > X_2$	0	0	0

The minimum payoff is obviously zero, while the maximum payoff is $X_2 - X_1$. Thus the maximum loss is $P_{t,1} - P_{t,2}$, while the maximum profit is $X_2 - X_1 + P_{t,1} - P_{t,2}$. The breakeven stock price is given by

$$X_2 - S_{T^*} - P_{t,2} + P_{t,1} = 0$$
$$\Rightarrow \quad S_{T^*} = X_2 - P_{t,2} + P_{t,1}$$

Example 12

Shirlene Kennedy has sold a put option with an exercise price of \$ 90 at a premium of \$ 1.49, and bought a put option with an exercise price of \$ 110, for a premium of \$ 10.51. The initial investment is \$ 10.51 – \$ 1.49 = \$ 9.02. This also represents the maximum loss from this strategy. The breakeven point is given by

$$110 - S_{T^*} - 9.02 = 0 \Rightarrow S_{T^*} = \$100.98$$

The maximum payoff from the strategy is \$ 20. Consequently the maximum profit is 20 – 9.02 = \$ 10.98.

The Convexity Property

Before we go on to analyze the next strategy, we need to establish an important result that must be satisfied by both call and put options.

Consider three exercise prices X_1,X_2, and X_3 such that $X_1 < X_2 < X_3$. Let $X_2 = wX_1 + (1 - w)X_3$. That is, X_2 is a weighted average of the other two exercise prices. If $C_{t,1}$, $C_{t,2}$, and $C_{t,3}$ represent the prices of the corresponding calls, we can show that

$$C_{t,2} \leq wC_{t,1} + (1 - w)\, C_{t,3}$$

Proof

Assume that $C_{t,2} > wC_{t,1} + (1 - w)\,C_{t,3}$

$$\Rightarrow\; C_{t,2} - wC_{t,1} - (1 - w)\,C_{t,3} > 0$$

Consider the following strategy. Sell a call with $X = X_2$; buy w calls with $X = X_1$; and buy $(1 - w)$ calls with $X = X_3$. The initial cash flow is $C_{t,2} - wC_{t,1} - (1 - w)C_{t,3}$ which by assumption is positive.

Let us now consider the payoffs from the portfolio at expiration.

Consider the total payoff for the price range $X_2 < S_T < X_3$, which is

$$(w - 1)\,(S_T - X_1) + (X_2 - X_1)$$

$$(w - 1) = \frac{X_1 - X_2}{X_3 - X_1}$$

$$\Rightarrow (w - 1)(S_T - X_1) + (X_2 - X_1)$$

$$= \left[\frac{X_1 - X_2}{X_3 - X_1}\right](S_T - X_1) + (X_2 - X_1)$$

$$= (X_2 - X_1)\left[1 - \frac{S_T - X_1}{X_3 - X_1}\right] \geq 0$$

Since the terminal cash flow in every scenario is non-negative, our assumption of a positive cash flow at inception is an indication of an arbitrage profit. Thus, to preclude arbitrage, we require that

$$C_{t,2} - wC_{t,1} - (1 - w)C_{t,3} \leq 0$$

$$\Rightarrow C_{t,2} \leq wC_{t,1} + (1 - w)C_{t,3}$$

A similar condition must hold for put options.

Table 1.12

Payoffs from Portfolio at Expiration

Terminal Price Range	*Payoff From Calls With* $X = X_1$	*Payoff From Calls With* $X = X_3$	*Payoff From Call With* $X = X_2$	*Total Payoff*
$S_T < X_1$	0	0	0	0
$X_1 < S_T < X_2$	$w(S_T - X_1)$	0	0	$w(S_T - X_1)$
$X_2 < S_T < X_3$	$w(S_T - X_1)$	0	$-(S_T - X_2)$	$(w - 1)(S_T - X_1)$
				$+ (X_2 - X_1)$
$S_T > X_3$	$w(S_T - X_1)$	$(1 - w)(S_T - X_3)$	$-(S_T - X_2)$	0

Butterfly Spread

With Calls

This strategy requires the investor to take a position in four options, with three different exercise prices. A long butterfly spread with calls requires the investor to buy an in the money as well as an out of the money call, and sell two calls which are at the money. Let us denote the exercise prices by X_1, X_2, and X_3, where $X_1 < X_2 < X_3$. The exercise prices are usually chosen such that $X_2 = \frac{(X_1 + X_3)}{2}$.

If we denote the corresponding option prices by $C_{t,1}$, $C_{t,2}$, and $C_{t,3}$, then from the convexity property

$$C_{t,2} < \frac{(C_{t,1} + C_{t,3})}{2} \Rightarrow 2C_{t,2} < C_{t,1} + C_{t,3}$$

Thus a long butterfly entails a net investment equal to $C_{t,1} + C_{t,3} - 2C_{t,2}$.

Let us consider the payoffs from the strategy at expiration.

Table 1.13

Payoffs from a Long Butterfly Spread

Terminal Price Range	*Payoff From Call With* $X = X_1$	*Payoff From Call With* $X = X_3$	*Payoff From Calls With* $X = X_2$	*Total Payoff*
$S_T < X_1$	0	0	0	0
$X_1 < S_T < X_2$	$S_T - X_1$	0	0	$S_T - X_1$
$X_2 < S_T < X_3$	$S_T - X_1$	0	$-2(S_T - X_2)$	$X_3 - S_T$
$S_T > X_3$	$S_T - X_1$	$S_T - X_3$	$-2(S_T - X_2)$	0

The minimum payoff is zero, which is realized if the terminal stock price is either below the lowest of the three exercise prices, or above the highest. In these scenarios the profit is equal to the initial investment, that is

$$\pi_{\min} = 2C_{t,2} - C_{t,1} - C_{t,3}$$

This amount represents the maximum loss from the strategy.

If $X_1 < S_T < X_2$, $\pi = S_T - X_1 + 2C_{t,2} - C_{t,1} - C_{t,3}$

If $X_2 < S_T < X_3$, $\pi = X_3 - S_T + 2C_{t,2} - C_{t,1} - C_{t,3}$

The maximum profit is realized when $S_T = X_2$, and is equal to

$X_2 - X_1 + 2C_{t,2} - C_{t,1} - C_{t,3}$ or $X_3 - X_2 + 2C_{t,2} - C_{t,1} - C_{t,3}$

There are two breakeven prices S_{T^*} and $S_{T^{**}}$

$$S_{T^*} = X_1 - 2C_{t,2} + C_{t,1} + C_{t,3}$$
$$S_{T^{**}} = X_3 + 2C_{t,2} - C_{t,1} - C_{t,3}$$

The profit diagram may be depicted as follows.

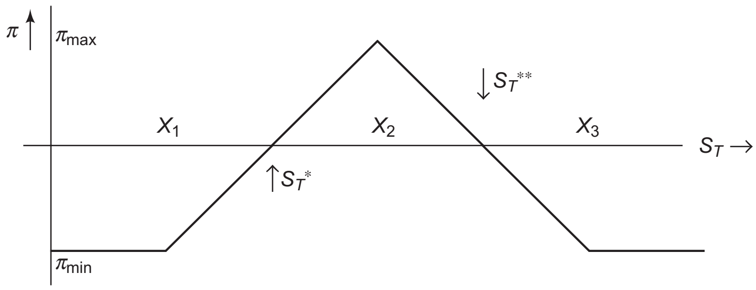

Fig. 1.11

Example 13

Caroline Jones has decided to take a long position in a butterfly spread. She wants to sell two options on IBM with an exercise price of \$ 100, and buy two options on the same stock with exercise prices of \$ 90 and \$ 110 respectively. All the options have three months to expiration. The premia of the options are listed in the table below.

Table 1.14

Premia for Call Options with Varying Exercise Prices

Exercise Price	*Call Premium*
\$ 90	\$ 13.71
\$ 100	\$ 7.22
\$ 110	\$ 3.20

The initial investment is $13.71 + 3.20 - 2 \times 7.22 = \$\ 2.47$. This is also the maximum possible loss from the strategy. The maximum profit is obtained at a terminal stock price of \$ 100, and is given by

$$100 - 90 + 2 \times 7.22 - 13.71 - 3.2 = \$\ 7.53$$

There are two breakeven prices:

$$S_T{}^{*} = 90 + 2.47 = \$\ 92.47$$

$$\text{and } S_T{}^{**} = 110 - 2.47 = \$\ 107.53$$

The maximum loss is equal to the net premium paid, which is $100 \times 2.47 = \$\ 247$. There are two breakeven prices, \$ 92.47 and \$ 107.53.

With Puts

A long butterfly spread can also be set up using put options. The investor should buy puts with exercise prices of X_1 and X_3, and sell two puts with an exercise price of X_2, where $X_1 < X_2 < X_3$ and $X_2 = \dfrac{(X_1 + X_3)}{2}$. If we denote the corresponding option prices by $P_{t,1}$, $P_{t,2}$, and $P_{t,3}$, then from the convexity property

$$2P_{t,2} < P_{t,1} + P_{t,3}$$

Table 1.15

Profit from the Butterfly Spread for Various Values of the Terminal Stock Price

Stock Price	*Payoff From Long Call with X = 90*	*Payoff From Long Call with X = 110*	*Payoff From Short Calls with X = 100*	*Total Profit/Loss*
80	0	0	0	(247)
85	0	0	0	(247)
90	0	0	0	(247)
92.47	247	0	0	0
95	500	0	0	253
100	1,000	0	0	753
105	1,500	0	(1,000)	253
107.53	1,753	0	(1,506)	0
110	2,000	0	(2,000)	(247)
115	2,500	500	(3,000)	(247)
120	3,000	1,000	(4,000)	(247)

Thus the strategy entails a net initial investment. The magnitude of this investment represents the maximum loss from the position, which arises if the terminal stock price is either below the lowest exercise price, or above the highest exercise price.

The maximum profit $= X_2 - X_1 + 2P_{t,2} - P_{t,1} - P_{t,3}$ or $X_3 - X_2 + 2P_{t,2} - P_{t,1} - P_{t,3}$. The breakeven stock prices are

$$S_{T^*} = X_1 - 2P_{t,2} + P_{t,1} + P_{t,3} \text{ and}$$

$$S_{T^{**}} = X_3 + 2P_{t,2} - P_{t,1} - P_{t,3}$$

The Condor

This strategy also entails the assumption of positions in four options. Consider four options with exercise prices X_1,X_2,X_3, and X_4, such that $X_1 < X_2 < X_3 < X_4$. Let $X_2 = \frac{(X_1 + X_3)}{2}$ and $X_3 = \frac{(X_2 + X_4)}{2}$. To set up a long condor, the investor has to buy two call options with exercise prices of X_1 and X_4 respectively, and sell two call options with exercise prices of X_2 and X_3 respectively.

The initial cash flow is $C_{t,2} + C_{t,3} - C_{t,1} - C_{t,4}$. From the convexity property of options

$$C_{t,2} < \frac{(C_{t,1} + C_{t,3})}{2} \text{ and}$$

$$C_{t,3} < \frac{(C_{t,2} + C_{t,4})}{2}$$

$$\Rightarrow \quad 2C_{t,2} + 2C_{t,3} < C_{t,1} + C_{t,3} + C_{t,2} + C_{t,4}$$

$$C_{t,2} + C_{t,3} - C_{t,1} - C_{T,4} < 0$$

Thus the long condor requires a net initial investment. Let us consider the payoffs from the strategy at expiration.

The minimum payoff from the position is zero, which occurs if $S_T < X_1$ or if $S_T > X_4$. Consequently the maximum loss is equal to the initial investment, which is $C_{t,2} + C_{t,3} - C_{t,1} - C_{t,4}$. The maximum payoff is $X_2 - X_1$, and thus the maximum profit is

$$X_2 - X_1 + C_{t,2} + C_{t,3} - C_{t,1} - C_{t,4}$$

There are two breakeven points, given by

$$S_{T^*} = X_1 - C_{t,2} - C_{t,3} + C_{t,1} + C_{t,4} \text{ and}$$

$$S_{T^{**}} = X_4 + C_{t,2} + C_{t,3} - C_{t,1} - C_{t,4}$$

Table 1. 16

Payoffs from a Long Condor

Terminal Price Range	*Payoff From Call With* $X = X_1$	*Payoff From Call With* $X = X_4$	*Payoff From Call With* $X = X_2$	*Pay off From Call With* $X = X_3$	*Total Payoff*
$S_T < X_1$	0	0	0	0	**0**
$X_1 < S_T < X_2$	$S_T - X_1$	0	0	0	$S_T - X_1$
$X_2 < S_T < X_3$	$S_T - X_1$	0	$-(S_T - X_2)$	0	$X_2 - X_1$
$X_3 < S_T < X_4$	$S_T - X_1$	**0**	$-(S_T - X_2)$	$-(S_T - X_3)$	$X_4 - S_T$
$S_T > X_4$	$S_T - X_1$	$S_T - X_4$	$-(S_T - X_2)$	$-(S_T - X_3)$	0

The profit diagram may be depicted as follows.

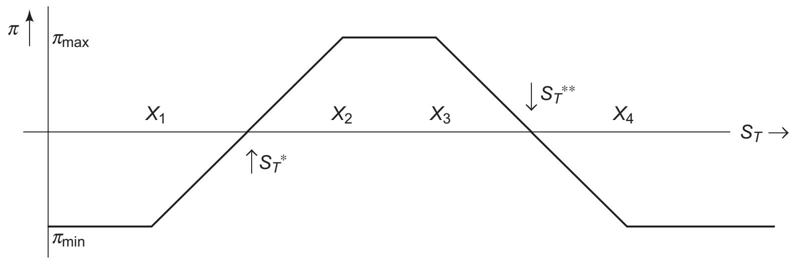

Fig. 1.12

Example 14

Andy Hunt has taken a long position in a condor by buying two call options on IBM with exercise prices of \$ 95 and \$ 110 respectively, and selling two call options with exercise prices of \$ 100 and \$ 105 respectively. All the options have three months to expiration. The premia of the options are listed in Table 10.17.

Table 1.17

Premia for Call Options with Varying Exercise Prices

Exercise Price	*Call Premium*
\$ 95	\$ 10.16
\$ 100	\$ 7.22
\$ 105	\$ 4.92
\$ 110	\$ 3.20

The initial investment is $10.16 + 3.20 – 7.22 – 4.92 =$ \$ 1.22. This is also the maximum possible loss from the strategy. The maximum profit is obtained in the price range $100 \leq S_T \leq 105$, and is equal to $105 – 100 – 1.22 =$ \$ 3.78. There are two breakeven prices:

$$S_{T^*} = 95 + 1.22 = \$\ 96.22 \text{ and}$$
$$S_{T^{**}} = 110 - 1.22 = \$\ 108.78$$

With Puts

A long condor can also be set up using put options. Consider four options with exercise prices such X_1, X_2,X_3, and X_4, rush that $X_1 < X_2 < X_3 < X_4$. Let $X_2 = \frac{(X_1 + X_3)}{2}$ and $X_3 = \frac{(X_2 + X_4)}{2}$. To set up a long condor, the investor has to buy two put options with exercise prices of X_1 and X_4 respectively, and sell two put options with exercise prices of X_2 and X_3 respectively.

Combinations

Combinations are strategies that involve taking positions in both calls and puts on the same stock.

The Straddle

A long straddle requires the investor to buy a call as well as a put option on a stock, with the same exercise price and expiration date. The position will yield a profit if the stock goes up or down substantially. The long call will pay off if the stock goes up in value, while the long put will pay off if the stock declines in value. The position is suitable for an investor who is anticipating a large price move, but is unsure about its direction.

The initial investment, which is the sum of the premia, is $C_t + P_t$. Let us consider the payoff table.

Table 1.18

Payoffs from a Long Straddle

Terminal Price Range	*Payoff From Call*	*Payoff From Put*	*Total Payoff*
$S_T < X$	0	$X - S_T$	$X - S_T$
$S_T > X$	$S_T - X$	0	$S_T - X$

If $S_T > X$, $\pi = S_T - X - P_t - C_t$. Thus the maximum profit is unlimited in this region. If $S_T < X$, $\pi = X - S_T - P_t - C_t$. The maximum profit in this region is $X - P_t - C_t$, which arises if the stock price declines to zero. Above X, the profit increases dollar for dollar with the stock price. Below X, as S_T goes from X to zero, the profit increases dollar for dollar. The maximum loss occurs at $S_T = X$, and is equal to $-(P_t + C_t)$. There are two breakeven points:

$$X - S_T{}^* - P_t - C_t = 0$$
$$\Rightarrow S_T{}^* = X - P_t - C_t, \text{ and}$$
$$S_T{}^{**} - X - P_t - C_t = 0$$
$$\Rightarrow S_T{}^{**} = X + P_t + C_t$$

The profit diagram may be depicted as follows.

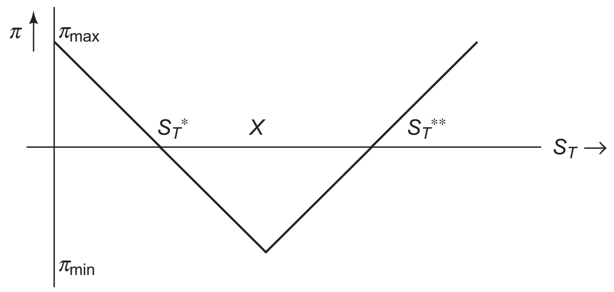

Fig. 1.13

Example 15

Mathew Henderson has bought a call option and a put option on IBM. Both options have an exercise price of $ 100, and have three months to expiration. The premium for the call is $ 7.22, while that for the put is $ 4.75. Thus the initial investment is 7.22 + 4.75 = $ 11.97. This amount represents the maximum potential loss from the strategy. If the stock price rises above the exercise price, the profit increases dollar for dollar. The profit for this price range is given by:

$$S_T - 100 - 11.97 = S_T - 111.97$$

The maximum profit is obviously unbounded.

If the terminal stock price declines below the exercise price, the profit again increases dollar for dollar. The profit in this price range is given by:

$$100 - S_T - 11.97 = 88.03 - S_T$$

The maximum profit is obviously $ 88.03. There are two breakeven points, $S_T{}^*$= $ 111.97, and $S_T{}^{**}$= $ 88.03.

The maximum loss occurs at a stock price of $ 100 and is equal to the premium paid for the two options, that is 100 × (7.22 + 4.75). There are two breakeven prices, $ 88.03 and $ 111.97.

The Strangle

This strategy, once again, requires the investor to buy a call and a put on the same stock. However, although the two options must have the same time to expiration, their exercise prices should be different. Let the call have an exercise price = X_1, and the put, an exercise price = X_2. There are two possibilities, $X_1 > X_2$, and $X_1 < X_2$. Consequently we have two types of strangles, called out-of-the money strangles and in-the-money strangles respectively. The initial cash flow, which is the sum of the premia, is given by $-(P_t + C_t)$.

Table 1.19

Profit from the Straddle for Various Values of the Terminal Stock Price

Stock Price	*Payoff From Long Call*	*Payoff From Long Put*	*Total Payoff*	*Total Profit/Loss*
80	0	2,000	2,000	803
85	0	1,500	1,500	303
88.03	0	1,197	1,197	0
90	0	1,000	1,000	(197)
95	0	500	500	(697)
100	0	0	0	(1,197)
105	500	0	500	(697)
110	1,000	0	1,000	(197)
111.97	1,197	0	1,197	0
115	1,500	0	1,500	303
120	2,000	0	2,000	803

An Out-of-the-money Strangle

Let us consider the payoff table from an out-of-the-money strangle.

Table 1.20

Payoffs from an Out-of-the-money Long Strangle

Terminal Price Range	*Payoff From Call*	*Payoff From Put*	*Total Payoff*
$S_T < X_2$	0	$X_2 - S_T$	$X_2 - S_T$
$X_2 < S_T < X_1$	0	0	0
$S_T > X_1$	$S_T - X_1$	0	$S_T - X_1$

If $S_T < X_2$, $\pi = X_2 - S_T - P_t - C_t$. The maximum profit in this region $= X_2 - P_t - C_t$. If $X_2 < S_T < X_1$, $\pi = -(P_t + C_t)$. If $S_T > X_1$, $\pi = S_T - X_1 - P_t - C_t$. The maximum profit in this region is unbounded. The maximum loss is $(P_t + C_t)$, which occurs in the region $X_2 < S_T < X_1$. There are two breakeven prices:

$$X_2 - S_T{}^* - P_t - C_t = 0$$
$$\Rightarrow S_T{}^* = X_2 - P_t - C_t$$
$$S_T{}^{**} - X_1 - P_t - C_t = 0$$
$$\Rightarrow S_T{}^{**} = X_1 + P_t + C_t$$

The profit diagram may be depicted as follows.

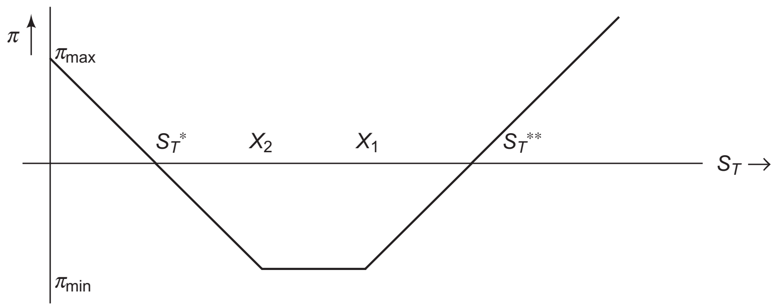

Fig. 1.14

Example 16

Ruth Kelly has bought a put option on IBM with an exercise price of \$ 95, and a call option on the same stock with an exercise price of \$ 105. The stock is currently priced at \$ 100, and both options have three months to expiration. The put premium is \$ 2.81 and the call premium is \$ 4.92. The initial investment is 2.81 + 4.92 = \$ 7.73, which is also the maximum potential loss. The position leads to a loss if the stock price at expiration is between \$ 95 and \$ 105. As the stock price declines below \$ 95, the profit increases dollar for dollar. The profit in this price range is given by $95 - S_T - 7.73 = \$\ 87.27 - S_T$. The maximum profit in this price range is \$ 87.27 which corresponds to a stock price of zero. The breakeven stock price is \$ 87.27.

As the stock price increases above \$ 105, the profit once again increases dollar for dollar. The profit in this price range is given by $S_T - 105 - 7.73 = S_T - 112.73$. The maximum profit is obviously unbounded. The breakeven stock price is \$ 112.73.

An In-the-money Strangle

Let us consider the payoff table from an in-the-money strangle.

If $S_T < X_1$, $\pi = X_2 - S_T - P_t - C_t$. The maximum profit in this region $= X_2 - P_t - C_t$. If $X_1 < S_T < X_2$, $\pi = X_2 - X_1 - (P_t + C_t)$. If $S_T > X_2$, $\pi = S_T - X_1 - P_t - C_t$. The maximum profit in this region is unbounded. The maximum loss is $X_2 - X_1 - (P_t + C_t)$, which occurs in the region $X_1 < S_T < X_2$. There are two breakeven prices:

$$X_2 - S_{T^*} - P_t - C_t = 0$$

$$\Rightarrow S_{T^*} = X_2 - P_t - C_t$$

$$S_{T^{**}} - X_1 - P_t - C_t = 0$$
$$\Rightarrow S_{T^{**}} = X_1 + P_t + C_t$$

Table 1.21

Payoffs from an In-of-the-money Long Strangle

Terminal Price Range	*Payoff From Call*	*Payoff From Put*	*Total Payoff*
$S_T < X_1$	0	$X_2 - S_T$	$X_2 - S_T$
$X_1 < S_T < X_2$	$S_T - X_1$	$X_2 - S_T$	$X_2 - X_1$
$S_T > X_2$	$S_T - X_1$	0	$S_T - X_1$

Example 17

Anne Smith has bought a call option on IBM with an exercise price of \$ 95, and a put option with an exercise price of \$ 105. The stock is currently priced at \$ 100, and both the options have three months to expiration. The call premium is \$ 10.16 and the put premium is \$ 7.33. The initial investment is 10.16 + 7.33 = \$ 17.49. The maximum possible loss is:

$$105 - 95 - 17.49 = -\$\ 7.49$$

As the stock price declines below \$ 95, the profit increases dollar for dollar. The profit in this price range is given by $105 - S_T - 17.49 = \$\ 87.51 - S_T$. The maximum profit in this price range is \$ 87.51 which corresponds to a stock price of zero. The breakeven stock price is \$ 87.51.

As the stock price increases above \$ 105, the profit once again increases dollar for dollar. The profit in this price range is given by $S_T - 95 - 17.49 = S_T - 112.49$. The maximum profit is obviously unbounded. The breakeven stock price is \$ 112.49.

The payoff diagram is identical to that for an out-of-the-money strangle.

A Strap

To go long in a strap, the investor needs to acquire calls and puts with the same exercise price and expiration date. The difference between a straddle and a strap is that, in the case of a strap, for every put that the investor buys, he needs to buy two calls. The initial investment is $2C_t + P_t$.

Let us consider the payoff table.

Table 1.22

Payoff from a strap

Terminal Price Range	*Payoff From Call*	*Payoff From Put*	*Total Payoff*
$S_T < X$	0	$X - S_T$	$X - S_T$
$S_T > X$	$2(S_T - X)$	0	$2(S_T - X)$

If $S_T < X$, $\pi = X - S_T - 2C_t - P_t$. The maximum profit in this region $= X - 2C_t - P_t$. If $S_T > X$, $\pi = 2S_T - 2X - 2C_t - P_t$. The maximum profit in this region is unlimited. The maximum loss occurs when $S_T = X$, and is equal to $-2C_t - P_t$, which is nothing but the initial investment. There are two breakeven points:

$$S_{T^*} = X - 2C_t - P_t$$

$$S_{T^{**}} = X + C_t + \frac{P_t}{2}$$

Consider the profit diagram.

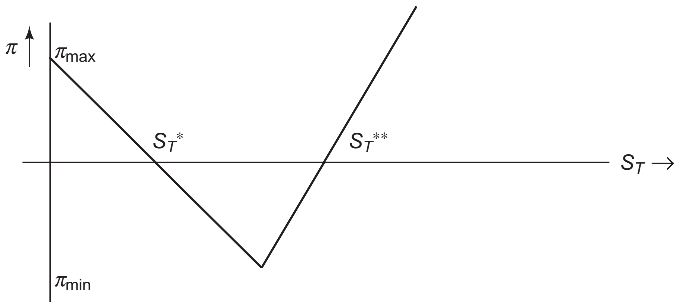

Fig. 1.15

As compared to a straddle, the upside breakeven stock price is easier to reach, and the downside breakeven stock price is harder to reach. Thus by increasing the bet on a bull market, the payoff in a bull market is higher, but the payoff in a bear market is lower. Investors who use straps consider an increase in price to be more likely than a decrease.

Example 18

Mitch Andrews has bought two call options and a put option on IBM. Both options have an exercise price of \$ 100, and have three months to expiration. The premium for the call is \$ 7.22, while that for the put is \$ 4.75. Thus the initial investment is $2 \times 7.22 + 4.75 = \$\ 19.19$. This amounts to the maximum potential loss from the strategy. If the stock price rises above the exercise price, the profit increases dollar for dollar. The profit for this price range is given by:

$$2S_T - 200 - 19.19 = 2S_T - 219.19$$

The maximum profit is obviously unbounded.

If the terminal stock price declines below the exercise price, the profit again increases dollar for dollar. The profit in this price range is given by:

$$100 - S_T - 19.19 = 80.81 - S_T$$

The maximum profit is obviously \$ 80.81. There are two breakeven points, S_T^{*} =\$ 109.595, and S_T^{**} =\$ 80.81

A Strip

A strip requires the investor to buy two puts and a call, with the same exercise price and time to expiration. Thus it tantamounts to a bigger bet on a bear market. The initial investment is $C_t + 2P_t$.

Let us consider the payoff table.

Table 1.23

Payoff from a strip

Terminal Price Range	*Payoff From Call*	*Payoff From Puts*	*Total Payoff*
$S_T < X$	0	$2(X - S_T)$	$2(X - S_T)$
$S_T > X$	$S_T - X$	0	$S_T - X$

If $S_T < X$, $\pi = 2X - 2S_T - 2P_t - C_t$. The maximum profit in this region $= 2X - 2P_t - C_t$. If $S_T > X$, $\pi = S_T - X - 2P_t - C_t$. The maximum profit in this region is unlimited. The maximum loss occurs when $S_T = X$, and is equal to $-2P_t - C_t$, which is nothing but the initial investment. There are two breakeven prices.

$$S_{T^*} = X - P_t - \frac{C_t}{2}$$

$$S_{T^{**}} = X + 2P_t + C_t$$

The profit diagram is as follows.

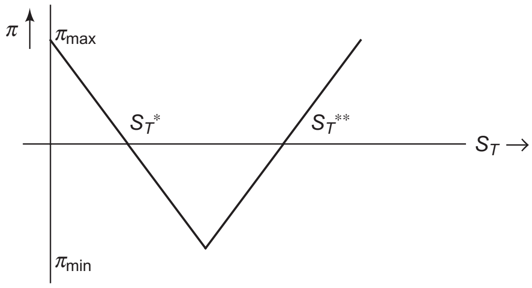

Fig. 1.16

As compared to a straddle, the upside breakeven stock price is harder to reach, and the downside breakeven stock price is easier to reach. Thus by increasing the bet on a bear market, the payoff in a bear market is higher, but the payoff in a bull market is lower. Investors who use straps consider a decrease in price to be more likely than an increase.

Example 19

Alice Keaton has bought two put options and a call option on IBM. Both options have an exercise price of \$ 100, and have three months to expiration. The premium for the call is \$ 7.22, while that for the put is \$ 4.75. Thus the initial investment is 7.22 + 2 x 4.75 = \$ 16.72. This amounts to the maximum potential loss from the strategy. If the stock price rises above the exercise price, the profit increases dollar for dollar. The profit for this price range is given by:

$$S_T - 100 - 16.72 = S_T - 116.72$$

The maximum profit is obviously unbounded.

If the terminal stock price declines below the exercise price, the profit again increases dollar for dollar. The profit in this price range is given by:

$$200 - 2S_T - 16.72 = 183.28 - 2S_T$$

The maximum profit is obviously \$ 183.28. There are two breakeven points, $S_{T^*} = \$\ 116.72$, and $S_{T^{**}} = \$\ 91.64$.

Box Spreads

A box spread is a combination of a bull spread with calls, and a bear spread with puts. Consider two exercise prices X_1 and X_2, such that $X_1 < X_2$. The strategy requires the investor to buy a call with an exercise price of X_1, and sell a call with an exercise price of X_2. It requires him to simultaneously sell a put with $X = X_1$, and buy a put with $X = X_2$. The initial cash flow is:

$$-C_{t,1} + C_{t,2} + P_{t,1} - P_{t,2} < 0$$

because $C_{t,1} > C_{t,2}$ and $P_{t,1} < P_{t,2}$.

Let us consider the payoff from the position at expiration.

As can be seen the payoff from the spread is independent of the terminal stock price. Thus the spread represents a riskless investment, and if it is correctly priced, the present value of the payoff at expiration discounted at the riskless rate, should equal the initial investment. If the present value exceeds the initial investment, the box spread will lead to an arbitrage profit. On the other hand, if the present value were to be less than the initial investment, an arbitrageur can make a riskless gain by reversing the positions, that is, by executing a short box spread.

Table 1.24

Payoffs from a Box Spread

Terminal Price Range	*Payoff From Call With* $X = X_1$	*Payoff From Call With* $X = X_2$	*Payoff From Put With* $X = X_1$	*Pay off From Put With* $X = X_2$	*Total Payoff*
$S_T < X_1$	0	0	$-(X_1 - S_T)$	$X_2 - S_T$	$X_2 - X_1$
$X_1 < S_T < X_2$	$S_T - X_1$	0	0	$X_2 - S_T$	$X_2 - X_1$
$S_T > X_2$	$S_T - X_1$	$-(S_T - X_2)$	0	0	$X_2 - X_1$

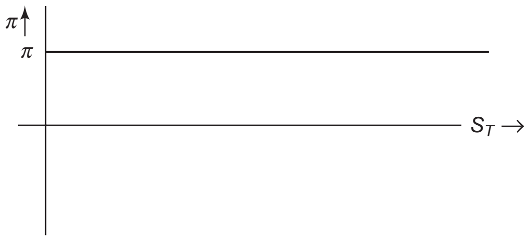

Fig. 1.17

Example 20

Ralph Fleming has bought a call option with $X = \$ \ 100$, and a put option with $X = \$ \ 110$. He has simultaneously sold a call option with $X = \$ \ 110$, and a put option with $X = \$ \ 100$. The initial investment is:

$$-7.22 + 3.22 - 10.51 + 4.75 = -\$ \ 9.76$$

The terminal payoff is $110 - 100 = \$ \ 10$. The rate of return is given by:

$$10 = 9.76e^{.25r} \Rightarrow r = 4[\ln(10) - \ln(9.76)] = .10 = 10\%$$

The rate of return of 10% is the value that we had used to obtain the option prices using the Black-Scholes formula. Since the options are fairly priced, it is but obvious that the box spread will yield the riskless rate that was assumed.

Appendix

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