NCFM

NSE's CERTIFICATION IN FINANCIAL MARKETS

Options Trading (Advanced) Module

NATIONAL STOCK EXCHANGE OF INDIA LIMITED

Test Details:

Sr. No.	Name of Module	Fees (Rs.)	Test Duration (in minutes)	No. of Questions	Maximum Marks	Pass Marks (%)	Certificate Validity
1	Financial Markets: A Beginners' Module *	1686	120	60	100	50	5
2	Mutual Funds : A Beginners' Module	1686	120	60	100	50	5
3	Currency Derivatives: A Beginner's Module	1686	120	60	100	50	5
4	Equity Derivatives: A Beginner's Module	1686	120	60	100	50	5
5	Interest Rate Derivatives: A Beginner's Module	1686	120	60	100	50	5
6	Commercial Banking in India: A Beginner's Module	1686	120	60	100	50	5
7	Securities Market (Basic) Module	1686	120	60	100	60	5
8	Capital Market (Dealers) Module *	1686	105	60	100	50	5
9	Derivatives Market (Dealers) Module *	1686	120	60	100	60	3
10	FIMMDA-NSE Debt Market (Basic) Module	1686	120	60	100	60	5
11	Investment Analysis and Portfolio Management Module	1686	120	60	100	60	5
12	Fundamental Analysis Module	1686	120	60	100	60	5
13	Financial Markets (Advanced) Module	1686	120	60	100	60	5
14	Securities Markets (Advanced) Module	1686	120	60	100	60	5
15	Mutual Funds (Advanced) Module	1686	120	60	100	60	5
16	Banking Sector Module	1686	120	60	100	60	5
17	Insurance Module	1686	120	60	100	60	5
18	Macroeconomics for Financial Markets Module	1686	120	60	100	60	5
19	NISM-Series-I: Currency Derivatives Certification Examination	1000	120	100	100	60	3
20	NISM-Series-II-A: Registrars to an Issue and Share Transfer Agents – Corporate Certification Examination	1000	120	100	100	50	3
21	NISM-Series-II-B: Registrars to an Issue and Share Transfer Agents – Mutual Fund Certification Examination	1000	120	100	100	50	3
22	NISM-Series-IV: Interest Rate Derivatives Certification Examination	1000	120	100	100	60	3
23	NISM-Series-V-A: Mutual Fund Distributors Certification Examination *	1000	120	100	100	50	3
24	NISM-Series-VI: Depository Operations Certification Examination	1000	120	100	100	60	3
25	NISM Series VII: Securities Operations and Risk Management Certification Examination	1000	120	100	100	50	3
26	Certified Personal Financial Advisor (CPFA) Examination	4495	120	80	100	60	3
27	NSDL–Depository Operations Module	1686	75	60	100	60 #	5
28	Commodities Market Module	2022	120	60	100	50	3
29	Surveillance in Stock Exchanges Module	1686	120	50	100	60	5
30	Corporate Governance Module	1686	90	100	100	60	5
31	Compliance Officers (Brokers) Module	1686	120	60	100	60	5
32	Compliance Officers (Corporates) Module	1686	120	60	100	60	5
33	Information Security Auditors Module (Part-1)	2528	120	90	100	60	2
	Information Security Auditors Module (Part-2)	2528	120	90	100	60	
34	Options Trading Strategies Module	1686	120	60	100	60	5
35	FPSB India Exam 1 to 4**	2247 per exam	120	75	140	60	NA
36	Examination 5/Advanced Financial Planning **	5618	240	30	100	50	NA
37	Equity Research Module ##	1686	120	65	100	55	2
38	Issue Management Module ##	1686	120	80	100	55	2
39	Market Risk Module ##	1686	120	50	100	55	2
40	Financial Modeling Module ###	1123	150	50	75	50	NA

* Candidates have the option to take the tests in English, Gujarati or Hindi languages.

\# Candidates securing 80% or more marks in NSDL-Depository Operations Module ONLY will be certified as 'Trainers'.

** Following are the modules of Financial Planning Standards Board India (Certified Financial Planner Certification)

- FPSB India Exam 1 to 4 i.e. (i) Risk Analysis & Insurance Planning (ii) Retirement Planning & Employee Benefits (iii) Investment Planning and (iv) Tax Planning & Estate Planning
- Examination 5/Advanced Financial Planning

\#\# Modules of Finitiatives Learning India Pvt. Ltd. (FLIP)

\#\#\# Module of IMS Proschool

The curriculum for each of the modules (except Financial Planning Standards Board India, Finitiatives Learning India Pvt. Ltd. and IMS Proschool) is available on our website: www.nseindia.com > Education > Certifications.

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Note: Candidates are advised to refer to NSE's website: www.nseindia.com, click on'Education' link and then go to 'Updates & Announcements' link, regarding revisions/updations in NCFM modules or launch of new modules, if any.

This book has been developed for NSE by Mr. Sundar Sankaran, Director, Finberry Academy Pvt. Ltd.

Chapter 1: Options – A Backgrounder

1.1 Derivative Types

Derivative is a contract that derives its value from the value of an underlying.The underlying may be a financial asset such as currency, stock and market index, an interest bearing security or a physical commodity. Depending on how the pay offs are structured, it could be a forward, future, option or swap.

- Both parties to a forward contract are committed. However, forwards are not traded in the market.
- In a futures contract too, both parties are committed. However, futures are tradable in the market.
- Options are contracts where only one party (writer / seller) is committed. The other party (buyer) has the option to exercise the contract at an agreed price (strike price), depending on how the price of the underlying moves. The option buyer pays the option writer a premium for entering into the contract.

  Unlike futures, where one party's profit is the counter-party's loss, the pay offs in an option contract are asymmetric. The downside for the option buyer is limited to the premium paid; the option seller has an unlimited downside.

  American options are exercisable any time until expiry of the contract; European options are exercisable only on expiry of the contract.

  Option contracts to *buy* an underlying are called "call" options; "put" options are contracts to *sell* an underlying.
- Swaps are contracts where the parties commit to exchange two different streams of payments, based on a notional principal. The payments may cover only interest, or extend to the principal (in different currencies) or even relate to other asset classes like equity.

The same exposure can be taken, either through the underlying cash market (debt, equity etc.) or a derivative (with debt, equity etc. as the underlying). A benefit of derivative is the leveraging. For the same outgo, it is possible to have a much higher exposure in the derivative market, than in the underlying cash market. This makes it attractive for speculaters and hedgers, besides normal investors.

1.2 Continuous Compounding

In valuation of many derivative contracts, the concept of continuous compounding is used:

$A = P \times e^{rn}$

where,

'A' is the amount

'P' is the principal

'e' is exponential function, which is equal to 2.71828

'r' is the continuously compounded rate of interest per period

'n' is the number of periods.

Rs. 5,000, continuously compounded at 6% for 3 months would be calculated to be Rs. 5,000 X $e^{(6\% \times 0.25)}$ i.e. Rs. 5,075.57.

Normal (discrete) compounding with the same parameters would have been calculated as Rs. 5,000 X $(1+6\%)^{0.25}$ i.e. Rs. 5,073.37.

A corollary of the formula is $P = A \times e^{-rn}$

1.3 Option Valuation

Options can be said to have two values – intrinsic value and time value.

A call option has intrinsic value if its exercise price (K) is lower than the prevailing market price (S_0). The intrinsic value would be equivalent to (S_0 – K). If the exercise price of a call is higher, it will be allowed to lapse i.e. it has zero value. Therefore, the intrinsic value of a call is given as Max (0, S_0 – K).

A put option has intrinsic value if its exercise price (K) is higher than the prevailing market price (S_0). The intrinsic value would be equivalent to (K - S_0). If the exercise price of a put is lower, it will be allowed to lapse i.e. it has zero value. Therefore, the intrinsic value of a put is given as Max (0, K - S_0).

Time value of an option is the excess that market participants are prepared to pay for an option, over its intrinsic value.

Suppose the premium quoted in the market for a call option with exercise price Rs. 15 is Rs. 3. The stock is quoting at Rs. 17.

Intrinsic value of the option is Max (0, 17 – 15) i.e. Rs. 2.

Time value is Rs. 3 – Rs. 2 i.e. Rs. 1.

The various factors that affect the value of an option (i.e. the option premium), and the nature of their influence on call and put options are given in Table 1.1.

Table 1.1

Option Valuation Parameters

Parameter	Impact on Option Valuationif Parameter is higher	
	Call	**Put**
Exercise Price	Lower	Higher
Spot Price	Higher	Lower
Time to Expiry	Higher (American Call)	Higher (American Put)
Volatility	Higher	Higher
Interest Rate	Higher	Lower
Stock Dividend	Lower	Higher

- Higher the exercise price, lower the intrinsic value of the call, if it is in the money. If it is out of the money, then lower the probability of it becoming in the money.
- Higher the spot price, higher the intrinsic value of the call.
- Longer the time to maturity, greater the possibility of exercising the option at a profist; therefore, higher the time value for both call and put options.
- More the fluctuation, the greater the possibility of the stock touching a price where it would be profitable to exercise the option.
- A call option can be seen as offering leverage – ability to take a large position with small fund outflow. Therefore, higher the interest rate, more valuable the option.
- After a stock dividend, the stock price corrects downwards. This will reduce the intrinsic value of a call option.

Binomial and Black Scholes are two approaches to option valuation that are discussed in Chapters 3 and 4 respectively.

1.4 Option Pricing Band

Given their nature, options have a band of realistic values. If the value goes beyond the band, then arbitrage opportunities arise. The band is defined as follows:

1.4.1 Upper Bound: Call Option

A call option on a stock represents the right to buy 1 underlying share. If the call option is priced higher than the price of the underlying share, then market participants will buy the underlying and write call options to earn riskless profits. Such arbitrage ensures that the price of a call option is lesser than or equal to the underlying stock price.

1.4.2 Upper Bound: Put Option

A put option on a stock represents the right to sell 1 underlying share at Price K. The put cannot have a value higher than K.

European put options can only be exercised at maturity. Their value today cannot be higher than the present value of the exercise price viz. Ke^{-rT}.

1.4.3 Lower Bound: Call Option

A call option cannot be priced lower than the difference between its stock price (S_0) and present value of its exercise price (Ke^{-rT}).

Suppose a stock is quoting at Rs. 50, while risk-free rate is 8%. A 3-month call on the stock with exercise price Rs. 48 is quoting at Rs. 2.50.

The present value of exercise price is Rs. 48 X $e^{-0.08x(3\div12)}$ i.e. Rs. 47.05.

The lower bound of the call option ought to be Rs. 50 – Rs. 47.05 i.e. Rs. 2.95.

If it is available at a lower value of Rs. 2.50, then there is an arbitrage opportunity. Investor will buy the call and sell the stock. This will provide a cash inflow of Rs. 50 – Rs. 2.50 i.e. Rs. 47.50. If this is invested for 3 months at the continuous compounded risk free rate of 8% p.a., it will grow to Rs. 47.50 x $e^{0.08 X (3\div12)}$ i.e. Rs. 48.46.

At the end of 3 months, if the stock is trading higher than Rs. 48, then the call will be exercised. The share thus acquired at Rs. 48 will be offered as delivery for the stock earlier sold. Investor is left with a riskless profit of Rs. 48.46 – Rs. 48 i.e. Rs. 0.46.

If the stock is trading lower than Rs. 48 at the end of 3 months – say at Rs. 45, investor will buy a share to square off the earlier sale. Investor is left with a riskless profit of Rs. 48.46 – Rs. 45 i.e. Rs. 3.46.

The scope for riskless profit will lead arbitragers to do such trades, which will push up the call option price above its lower bound.

1.4.4 Lower Bound: Put Option

A put option cannot be priced lower than the difference between the present value of its exercise price (Ke^{-rT}) and its stock price (S_0).

Suppose a stock is quoting at Rs. 50, while risk-free rate is 8%. A 3-month put on the stock with exercise price Rs. 52 is quoting at Rs. 0.50.

The present value of exercise price is Rs. 52 X $e^{-0.08x(3\div12)}$ i.e. Rs. 50.97.

The lower bound of the put option ought to be Rs. 50.97 – Rs. 50 i.e. Rs. 0.97.

If it is available at a lower value of Rs. 0.50, then there is an arbitrage opportunity. Investor will buy the put and the stock. This will require investment of Rs. 50 + Rs. 0.50 i.e. Rs. 50.50. Suppose the arbitrageur borrows the amount at 8%. He will have to repay Rs. 50.50 x $e^{0.08 \times (3 \div 12)}$ i.e. Rs. 51.52 at the end of 3 months.

At the end of 3 months, if the stock is trading below Rs. 52, then the put will be exercised. The share acquired earlier will be sold at Rs. 52. Only Rs. 51.52 is to be repaid. The balance Rs. 0.48 is the arbitrageur's profit.

If the stock is trading above Rs. 52 at the end of 3 months – say at Rs. 55, investor will sell the share and repay the loan. Investor is left with a riskless profit of Rs. 55 – Rs. 51.52 i.e. Rs. 3.48.

The scope for riskless profit will lead arbitragers to do such trades, which will push up the put option price above its lower bound.

1.5 Put-Call Parity: European Options

Consider two positions as follows:

Position A: 1 European Call Option + Ke^{-rT} Cash

The cash will grow to K at the risk-free rate. At time T, if share price is higher than K, then the call option will be exercised. Else, investor will keep the cash. Thus, at Time T, Position A will be worth max (K, S_T).

Position B: 1 European Put Option + 1 Underlying Share

At time T, if share price is lower than K, then the put option will be exercised to sell the share at K. Else, investor will keep the share and let the option lapse. Thus, at Time T, Position B too will be worth max (K, S_T).

Since both the call and the put are European, they cannot be exercised before maturity. Therefore, if the two positions are equal at time T, then they should be equal at any time before maturity, including at time 0. This gives the Put-Call Parity formula

$C + Ke^{-rT} = P + S_0$

When parity is not maintained, arbitrage opportunities arise.

Suppose a stock is quoting at Rs. 50, while risk-free rate is 8%. A 3-month call on the stock with exercise price Rs. 48 is quoting at Rs. 3.00.

Substituting in the earlier formula, we get

Rs. 3 + Rs. 48 X $e^{-8\% \times (3 \div 12)}$ = P + Rs. 50

Rs. 3 + Rs. 47.05 = P + Rs. 50

P = Rs. 1.05

Based on Put-Call parity, the put should be priced at Rs. 1.05.

1.5.1 Position A undervalued

Suppose the put is priced at Rs. 0.75, while call is at Rs. 3.

The valuation of the two positions is as follows:

Position A = Rs. 3 + Rs. 48 X $e^{-8\% \times (3 \div 12)}$

i.e.Rs. 3 + Rs. 47.05

i.e. Rs. 50.05

Position B = Rs. 0.75 + Rs. 50

i.e. Rs. 50.75.

Position B is overvalued, as compared to Position A. It would be logical to buy Position A and short Position B. This would entail the following transactions:

- Buy 1 European Call with exercise price Rs. 48 at Rs. 3
- Sell 1 share at Rs. 50
- Sell 1 European Put with exercise price Rs. 48 at Rs. 0.75

As a result, the arbitrageur will be left with Rs. 50 + Rs. 0.75 – Rs. 3 i.e. Rs. 47.75. At the risk free rate of 8% for 3 months, it will mature to Rs. 47.75 X $e^{-8\% \times (3 \div 12)}$i.e. Rs. 48.71.

On maturity, if the share price is higher than Rs. 48, say, it is Rs. 49. The call will be exercised to get the share at Rs. 48. The put will lapse. The investor will be left with Rs. 48.71 – Rs. 48.00 i.e. Rs. 0.71.

On maturity, if the share price is lower than Rs. 48, say, it is Rs. 47. The call will be allowed to lapse. The put will get exercised, on account of which the arbitrageur will get a share at Rs. 48. This will be given as delivery for the share which was earlier sold for Rs. 50. Investor will be left with Rs. 48.71 – Rs. 48 i.e. Rs. 0.71

1.5.2 Position B Undervalued

Suppose the put is priced at Rs. 0.75, while call is at Rs. 5.

The valuation of the two positions is as follows:

Position A = Rs. 5 + Rs. 48 X $e^{-8\% \times (3 \div 12)}$

i.e.Rs. 5 + Rs. 47.05

i.e. Rs. 52.05

Position B = Rs. 0.75 + Rs. 50

i.e. Rs. 50.75.

Position A is overvalued, as compared to Position B. It would be logical to buy Position B and short Position A. This would entail the following transactions:

- Sell 1 European Call with exercise price Rs. 48 at Rs. 5
- Buy 1 share at Rs. 50
- Buy 1 European Put with exercise price Rs. 48 at Rs. 0.75

The arbitrageur has a cash outflow of Rs. 50 + Rs. 1.75 – Rs. 5 i.e. Rs. 46.75.If this is borrowed at the risk-free rate, an amount of Rs. 46.75 X $e^{8\% \times (3 \div 12)}$i.e. Rs. 47.69 is payable on maturity.

On maturity, if the share price is higher than Rs. 48, say, it is Rs. 49. The call will get exercised, for which the share is already held. The arbitrageur will receive Rs. 48, which will be used to repay the loan. The put will be allowed to lapse. The investor will be left with Rs. 48 – Rs. 47.69 i.e. Rs. 0.31.

On maturity, if the share price is lower than Rs. 48, say, it is Rs. 47. The call will be allowed to lapse. The put will be exercised, to sell the share at Rs. 48. Out of this, the loan will be repaid. Investor will be left with Rs. 48 – Rs. 47.69 i.e. Rs. 0.31

The Put-Call parity formula can be re-written, so that, C – P should be $S_0 - Ke^{-rT}$ i.e. Rs. 2.95. If not, arbitrage opportunities exist.

1.6 Put-Call Parity: American Options

The Put-Call Parity formula for American options can be defined as

$S_0 - K \leq C - P \leq S_0 - Ke^{-rT}$

Continuing with the earlier example,

$50 - 48 \leq C - P \leq 50 - 48e^{-10\% \times (3 \div 12)}$

$2 \leq C - P \leq 50 - 47.05$

$2 \leq C - P \leq 50 - 47.05$

Rs. $2 \leq C - P \leq$ Rs. 2.95

Thus, C – P should lie between Rs. 2 and Rs. 2.95.

If C is Rs. 3, then P should be between Rs. 1 and Rs. 0.05. If not, then arbitrage opportunities exist.

1.7 Dividends

The discussions so far assumed that the stock does not pay a dividend. Suppose D is the present value of dividend expected during the life of the contract.

The lower bound for an European call option on the stock can be defined as $C \geq S_0 - D - Ke^{-rt}$

The lower bound for an European put option on the stock can be defined as $P \geq D + Ke^{-rt} - S_0$

Put-Call Parity formula for European options can be defined as

$C + D + Ke^{-rT} = P + S_0$

Put-Call Parity formula for American options can be defined as

$S_0 - D - K \leq C - P \leq S_0 - Ke^{-rT}$

Points to remember

- Derivative is a contract that derives its value from the value of an underlying. The underlying may be a financial asset such as currency, stock and market index, an interest bearing security or a physical commodity.
- Depending on how the pay offs are structured, a derivativecontract could be a forward, future, option or swap.
- Both parties to a forward contract are committed. However, forwards are not traded in the market.
- In a futures contract too, both parties are committed. However, futures are tradable in the market.
- Options are contracts where only one party (writer / seller) is committed. The other party (buyer) has the option to exercise the contract at an agreed price (strike price), depending on how the price of the underlying moves.
- American options are exercisable any time until expiry of the contract; European options are exercisable only on expiry of the contract.
- Option contracts to buy an underlying are called "call" options; "put" options are contracts to sell an underlying.
- Swaps are contracts where the parties commit to exchange two different streams of payments, based on a notional principal. The payments may cover only interest, or extend to the principal (in different currencies) or even relate to other asset classes like equity.
- A benefit of derivative is the leveraging. For the same outgo, it is possible to have a

much higher exposure in the derivative market, than in the underlying cash market. This makes it attractive for speculaters and hedgers, besides normal investors.

- Continuous compounded value is determined with the formula $A = P \times e^{rn}$

where,

'A' is the amount

'P' is the principal

'e' is exponential function, epsilon, which is equal to 2.71828

'r' is the continuously compounded rate of interest per period

'n' is the number of periods.

A corollary of the formula is $P = A \times e^{-rn}$

- Options can be said to have two values – intrinsic value and time value.
  - A call option has intrinsic value if its exercise price (K) is lower than the prevailing market price (S_0). The intrinsic value would be equivalent to (S_0 – K). If the exercise price of a call is higher, it will be allowed to lapse i.e. it has zero value. Therefore, the intrinsic value of a call is given as Max (0, S_0 – K).
  - A put option has intrinsic value if its exercise price (K) is higher than the prevailing market price (S_0). The intrinsic value would be equivalent to (K - S_0). If the exercise price of a put is lower, it will be allowed to lapse i.e. it has zero value. Therefore, the intrinsic value of a put is given as Max (0, K - S_0).
  - Time value of an option is the excess that market participants are prepared to pay for an option, over its intrinsic value.
- Value of an option (its premium) is influenced by exercise price, spot price, time to expiry, volatility, interest rate and stock dividend.
- Binomial and Black Scholes are two approaches to option valuation.
- Given their nature, options have a band of realistic values. If the value goes beyond the band, then arbitrage opportunities arise.
  - The price of a call option is lesser than or equal to the underlying stock price.
  - The put cannot have a value higher than K.
  - European put options can only be exercised at maturity. Their value today cannot be higher than the present value of the exercise price viz. Ke^{-rT}.
  - A call option cannot be priced lower than the difference between its stock price (S_0)

and present value of its exercise price (Ke^{-rT}).

- A put option cannot be priced lower than the difference between the present value of its exercise price (Ke^{-rT}) and its stock price (S_0).
- Put- call parity for European options without a dividend is given by the formula $C + Ke^{-rT} = P + S_0$
- The Put-Call Parity formula for American options can be defined as

  $S_0 - K \le C - P \le S_0 - Ke^{-rT}$
- The lower bound for an European call option on the stock can be defined as

  $C \ge S_0 - D - Ke^{-rt}$
- The lower bound for an European put option on the stock can be defined as

  $P \ge D + Ke^{-rt} - S_0$
- Put-Call Parity formula for European options can be defined as

  $C + D + Ke^{-rT} = P + S_0$
- Put-Call Parity formula for American options can be defined as

  $S_0 - D - K \le C - P \le S_0 - Ke^{-rT}$

Self-Assessment Questions

- Which of the following is a contract where both parties are committed
  - Forward
  - Future
  - Option
  - **Both the above**
- Swaps can be based on
  - Interest
  - Principal and Interest
  - Equity
  - **Any of the above**
- An option to buy an underlying is called
  - Forward
  - **Call**

- Put
- None of the above

- If the security is priced at Rs. 300, what will be the price in 1 month, taking continuous compounding rate of 7%?
  - Rs. 321
  - Rs. 301.75
  - **Rs. 301.76**
  - Rs. 301.74

- Which of the following is exercisable before expiry?
  - Forward
  - Future
  - **American call**
  - European put

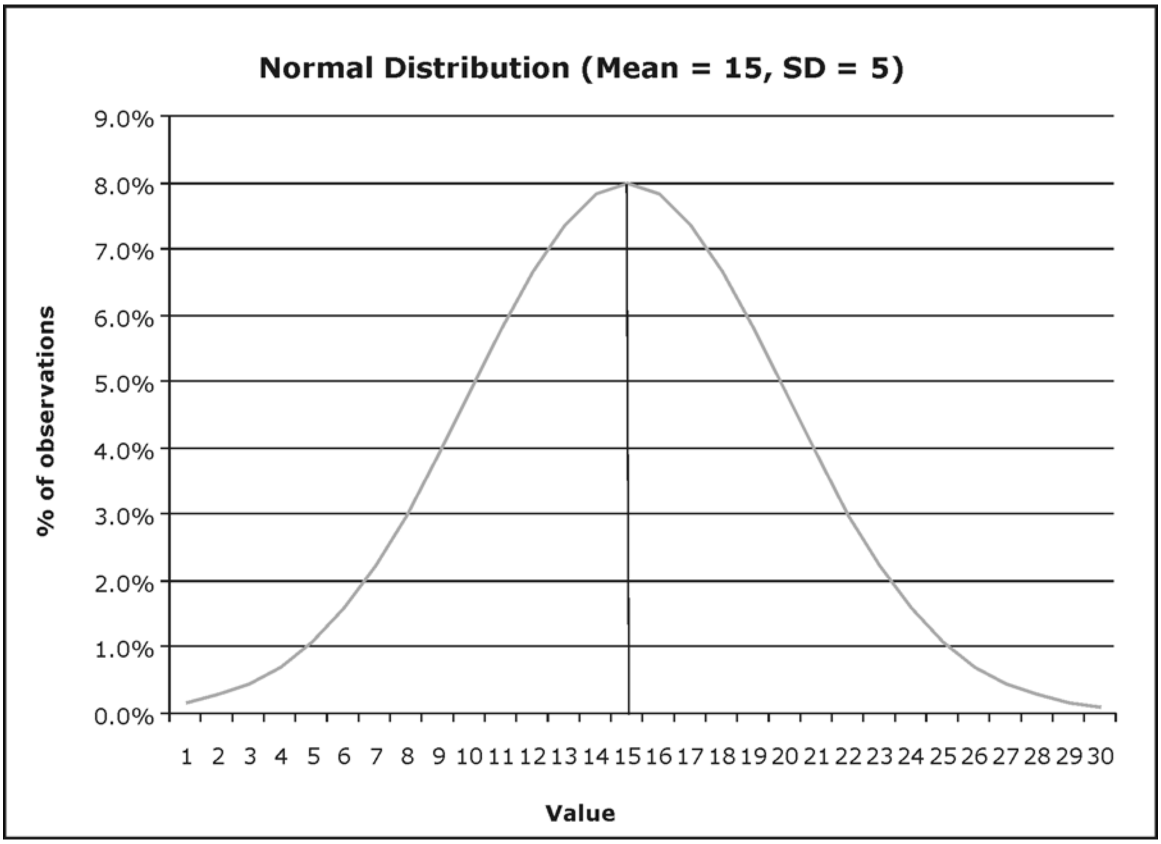
Chapter 2: Quantitative Concepts – A Backgrounder

2.1 Normal Distribution

Various financial models make different assumptions regarding the pattern of distribution of the data. Given a distribution, various other interpretations become possible. One such distribution is the Normal Distribution, commonly denoted by the 'Φ' (Greek phi symbol).

A normal distribution is defined by its mean and standard deviation. Thus, Φ (15, 5) refers to a normal distribution with mean of 15 and standard deviation of 5. It is depicted in the form of a bell-shaped curve, as shown in Figure 2.1.

Figure 2.1



In a normal distribution, the following are assumed:

- Mean = Median = Mode. In the above case, it is 15.
- The curve is symmetric on both sides.
- Each half of the curve (left and right of the mean) covers 50% of the area under the curve.

- The normal distribution table (Annexure 1) shows the area to the left of a desired point on the X-axis, referred to as Z. For Z = 1.23, one first goes down the first column to 1.2 – and then goes towards the right for the value under '0.03' viz. 0.8907. For example, reading from the first row of the table:
  - Z = 0.00 gives a value of 0.50. This means that 50% of the area under the curve is to the left of Mean + 0 times Standard Deviation (i.e. the mean). Since the curve is symmetric, 50% of the area under the curve is also to the right of the mean.
  - Z = 0.01 gives a value of 0.5040. This means that 50.40% of the area under the curve is to the left of Mean + 0.01 Standard Deviation.
  - Z = 1.96 gives a value of 0.975. This means that 97.5% of the area under the curve is to the left of Mean + 1.96 Standard Deviation. Of this, 50% is to the left of the mean. Therefore, the area between Mean and Mean + 1.96 Standard Deviation covers 97.5% - 50% i.e. 47.5% of the area under the curve.

    Since the curve is symmetric, the area between Mean and 'Mean – 1.96 Standard Deviation' too would cover 47.5% of the area under the curve.

    Thus, Mean ± 1.96 Standard Deviation would cover 47.5% + 47.5% i.e. 95% of the area under the curve.

    This means that if the returns on a stock are normally distributed with mean of 8% and standard deviation of 1%, then it can be said that there is a 95% probability of the stock return being 8% ± (1.96 X 1%) i.e. between 6.04% and 9.96%.
- It can similarly be shown from the normal distribution table that:
  - Mean ± 1 Standard Deviation covers 68.27% of the area under the curve.
  - Mean ± 2 Standard Deviation covers 95.45% of the area under the curve.
  - Mean ± 3 Standard Deviation covers 99.73% of the area under the curve.

2.2 Share Prices – Lognormal Distribution

Share prices can go up to any level, but they cannot go below zero. Because of this asymmetric nature of share prices, normal distribution is not a suitable assumption to capture the behaviour of *share prices*. However, the *returns from the shares* over short periods of time can be said to be normally distributed.

If a share has gone up from Rs. 50 to Rs. 55, we know the discrete return is (Rs. 5 ÷ Rs. 50 X 100) i.e. 10%. The continuously compounded return can be calculated as ln (55÷ 50) i.e. 9.53% (The Excel function 'ln' calculates the natural logarithm of the number within the brackets).

The price of a share in future is a function of today's price (a constant) and its return (which is normally distributed for short periods of time). Since, log of a stock price in future is assumed to be normally distributed, stock prices are said to be log normally distributed.

Several models, including Black-Scholes, assume that during short periods of time, percentage change in stock prices (which is the return in a non-dividend paying stock) is normally distributed.

2.3 Linkages that arise from the Distribution

If 'S' is the stock price, and 'x' is the continuously compounded rate of return realised between time 0 and time T, then

$$S_t = S_0 e^{xT} \tag{3.1}$$

where, 'e' is Epsilon i.e. a value of 2.71828

$$x = \frac{1}{T} \ln \frac{S_T}{S_0} \tag{3.2}$$

Let us denote expected annual return on a stock as μ (mu), annual volatility of the stock price as σ (sigma), change in stock price as ΔS, and the short time period of change in stock price as Δt.

$$x \sim \Phi \left[\left(\mu - \frac{\sigma^2}{2}\right), \sigma \div \sqrt{T}\right] \tag{3.3}$$

i.e. x (the continuously compounded stock return)is a normal distribution with mean = $\left(\mu - \frac{\sigma^2}{2}\right)$ and standard deviation = $\sigma \div \sqrt{T}$

The percentage change in stock price in time Δt approximates a normal distribution with:

- Mean = $\mu\Delta t$
- Standard deviation = $\sigma\sqrt{\Delta t}$

i.e. $\frac{\Delta S}{S} \sim \Phi\ (\mu\Delta t, \sigma\sqrt{\Delta t})$ (3.4)

From this, the following implications follow:

$$(\ln S_t - \ln S_0) \sim \Phi \left[\left(\mu - \frac{\sigma^2}{2}\right)T, \sigma\sqrt{T}\right] \tag{3.5}$$

$$\ln (S_t \div S_0) \sim \Phi \left[\left(\mu - \frac{\sigma^2}{2}\right)T, \sigma\sqrt{T}\right] \tag{3.6}$$

$$\ln S_t \sim \Phi \left[\ln S_0 + \left(\mu - \frac{\sigma 2}{2}\right)T, \ \sigma\sqrt{T}\right] \tag{3.7}$$

i.e. $\ln S_t$ is a normal distribution with mean = $\left[\ln S_0 + \left(\mu - \frac{\sigma 2}{2}\right)T\right]$ and standard deviation = $\sigma\sqrt{T}$

A variable with log normal distribution can take values between zero and infinity. A log normal distribution is skewed to one side (not symmetric like a normal distribution). Therefore, the 'mean = median = mode' property is not applicable. If $E(S_T)$ denotes the expected stock price in time T, and Var (S_T) denotes variance in $S_{T,}$ it can be shown that:

$$E(S_T) = S_0 e^{\mu t} \tag{3.8}$$

$$Var(S_T) = S_0^2 e^{2\mu t} \; (e\sigma^2 t - 1) \tag{3.9}$$

The application of such formulae would be clear from the following examples:

Example 2.1

Suppose a share is currently valued at Rs. 15. Its annual volatility is 30%, while expected return is 25% p.a. What is the likely range of values of the stock price in 3 months, at 95% confidence level?

$$\ln S_t \sim \Phi\left[\text{In}S_0 + \left(\mu - \frac{\sigma 2}{2}\right)T,\ \ \sigma\sqrt{T}\right] \tag{3.7}$$

We know that S_0 = Rs. 15; σ = 30%; μ = 25%

T = 3 ÷ 12

Z score for 95% confidence level is 1.96

Substituting in 3.7, we get

$$\ln S_t \sim \Phi\ \left[\text{In}\ (15) + \left(.25 - \frac{3^2}{2}\right)(3 \div 12),\ .3\sqrt{0.25}\right]$$

i.e. ~ Φ (2.7593, .15)

This means that the log of the stock price in 3 months approximates a normal distribution with mean = 2.7593 and standard deviation = .15.

With 95% confidence, we can say the range of values of $\ln S_t$ is:

Lower end:

Mean – 1.96 Standard Deviation

i.e. 2.7593 – 1.96 X .15

i.e. 2.4653

Higher end:

Mean + 1.96 Standard Deviation

i.e. 2.7593 + 1.96 X .15

i.e. 3.0533

The range of values is defined as $2.4653 < \ln S_t < 3.0533$.

We want to find the range of values of the stock price i.e. S_t. This is

$e^{2.4653} < S_t < e^{3.0533}$

i.e. $11.77 < S_t < 21.19$

With 95% confidence level, it can be said that in 3 months, the stock will be between Rs. 11.77 and Rs. 21.19.

Continuing with the same example, what is expected stock price and variance of the stock price in 3 months?

$$E(S_T) = S_0 e^{\mu t} \qquad (3.8)$$

Substituting in 3.8, we get:

$E(S_T) = 15 \text{ X } 2.71828^{.25 \text{ X } (3\div 12)}$

i.e. Rs. 15.97

The expected stock price in 3 months is therefore Rs. 15.97.

$$Var(S_T) = S_0^{\,2} e^{2\mu t}\left(e\sigma^2 t - 1\right) \qquad (3.9)$$

Substituting in 3.9, we get:

$Var(S_T) = 15^2 \text{X } 2.71828^{2 \times .25 \times (3\div 12)}\left(2.71818^{.3^2(3\div 12)} - 1\right)$

i.e. 5.80

Taking the example further, what is the mean and standard deviation of its continuously compounded average rate of return?

$$x \sim \Phi\left[\left(\mu - \frac{\sigma^2}{2}\right), \sigma \div \sqrt{T}\right] \qquad (3.3)$$

x is a normal distribution with the following parameters:

Mean = $\left(\mu - \frac{\sigma^2}{2}\right)$

i.e. $\left(0.25 - \frac{.3^2}{2}\right)$

i.e. 20.50%

Standard Deviation = $\sigma \div \sqrt{T}$

i.e. $3 \div \sqrt{(3 \div 12)}$

i.e. 60%.

With 95% confidence level, it can be said that x will be between 20.50% ± 1.96 X 60% i.e. -97.10% < x < 138.10%.

The above range is obviously very wide. Over short periods of time, this is a problem.

The range for a 3-year period (instead of 3 months), is much narrower at

-13.45% < x < 54.45%.

2.4 Volatility (σ)

Volatility of a stock is a measure of the uncertainty of the annual returns provided by it. It is an important input that affects the valuation of options, as will be seen in the following chapters.

Estimation of volatility is discussed in Chapter 6.

Points to remember

- Various financial models make different assumptions regarding the pattern of distribution of the data. Given a distribution, various other interpretations become possible. One such distribution is the Normal Distribution.
- Normal Distribution is commonly denoted by the 'Φ' (Greek phi symbol). It is defined by its mean and standard deviation, and takes the form of a bell-shaped curve.
- In a normal distribution, the following are assumed:
  - Mean = Median = Mode. In the above case, it is 15.
  - The curve is symmetric on both sides.
  - Each half of the curve (left and right of the mean) covers 50% of the area under the curve.
  - Mean ± 1 Standard Deviation covers 68.27% of the area under the cover.
  - Mean ± 2 Standard Deviation covers 95.45% of the area under the cover.
  - Mean ± 3 Standard Deviation covers 99.73% of the area under the cover.
- Normal distribution is not a suitable assumption to capture the behaviour of share prices. However, the returns from the shares over short periods of time can be said to be normally distributed.Since, log of a stock price in future is assumed to be normally distributed, stock prices are said to be log normally distributed.
- Several models, including Black-Scholes, assume that during short periods of time, percentage change in stock prices (which is the return in a non-dividend paying stock) is normally distributed.
- Important formulae:
  - $S_t = S_0 e^{xT}$ (3.1)

    where, 'e' is Epsilon i.e. a value of 2.71828
  - $x = \frac{1}{T} \ln \frac{S_T}{S_0}$ (3.2)
  - $x \sim \Phi \left[\left(\mu - \frac{\sigma^2}{2} \right), \sigma \div \sqrt{T} \right]$ (3.3)

- $\frac{\Delta S}{S} \sim \Phi\,(\mu\Delta t, \sigma\sqrt{\Delta t})$ (3.4)
- $(\ln S_t - \ln S_0) \sim \Phi\left[\left(\mu - \frac{\sigma^2}{2}\right)T, \sigma\sqrt{T}\right]$ (3.5)
- $\ln (S_t \div S_0) \sim \Phi\left[\left(\mu - \frac{\sigma^2}{2}\right)T, \sigma\sqrt{T}\right]$ (3.6)
- $\ln S_t \sim \Phi\left[\ln S_0 + \left(\mu - \frac{\sigma 2}{2}\right)T,\ \sigma\sqrt{T}\right]$ (3.7)
- $E(S_T) = S_0 e^{\mu t}$ (3.8)
- $Var(S_T) = S_0^{\,2} e^{2\mu t}\,(e\sigma^2 t - 1)$ (3.9)

- Volatility of a stock is a measure of the uncertainty of the annual returns provided by it.

Self-Assessment Questions

❖ Normal distribution is denoted by the following symbol

- ND
- Δ
- **Φ**
- Π

❖ Mean ± 2 Standard Deviation covers _____% of the area under the curve.

- **95.45**
- 68.27
- 99.73
- 62.50%

❖ Normal distribution is a suitable assumption to capture the behaviour of stock prices.

- True
- **False**

❖ The value of 'e' is

- 2.81728
- 2.71282
- **2.71828**
- 2.82718

❖ Volatility is of little practical relevance in estimation the value of options.

- True
- **False**

Chapter 3: Binomial Option Pricing Model

The binomial model assumes that in a short period of time a stock can take either of two prices – one higher and one lower than the current stock price. The binomial tree built on this basis can be used to value various options.

3.1 Single Period Binomial

Suppose the current stock price is Rs. 50. It can go up 10% to Rs. 55 or go down 10% to Rs. 45. What should be the value of a 1-month European call option having exercise price of Rs. 48, if the risk-free rate is 8% p.a.?

The up factor 'u' is 1 + 10% i.e. 1.1.

The down factor 'd' is 1 – 10% i.e. 0.9

The risk-free rate, 'r' is 8% p.a.

Time, 'T' is 1 month i.e. 1÷ 12 years.

If 'p*' is the probability of the share going up 10%, then '1-p*' is the probability of it going down 10% (since the model assumes only two possible price movements).

In a risk-neutral environment, with continuous compounding, the value of 'p*' can be calculated to be:

$(e^{rT} - d) \div (u - d)$

i.e. $(2.71828^{(8\% \times 1 \div 12)} - 0.9) \div (1.1 - 0.9)$

i.e. 53.34%

Calculation of risk-neutral price (at the end of 1 month) and risk-free return can be seen in Table 3.1 below:

Table 3.1

Z21 f_x =Z17+Z15

	U	V	W	X	Y	Z	AA
12							
13	1	2	3	4	5	6 = 2 X 5	7 = 3 X 5
14							
15	Up	10%	55.00	P*	53.34%	5.3344%	29.34
16							
17	Down	10%	45.00	1 - P*	46.66%	-4.6656%	20.99
18							
19	Risk Neutral Price	(Total of Column 7)					50.33
20							
21	Risk Free Return	(Total of Column 6)				0.67%	
22							

The continuously compounded risk-free return for 1 month can be cross-checked with the formula $e^{rT} - 1$

i.e. $2.71828^{(8\% \times 1 \div 12)} - 1$

i.e. 0.67%

Rs. 50.33 is the risk-neutral value at the end of time T. Its present value can be calculated with continuous compounding as:

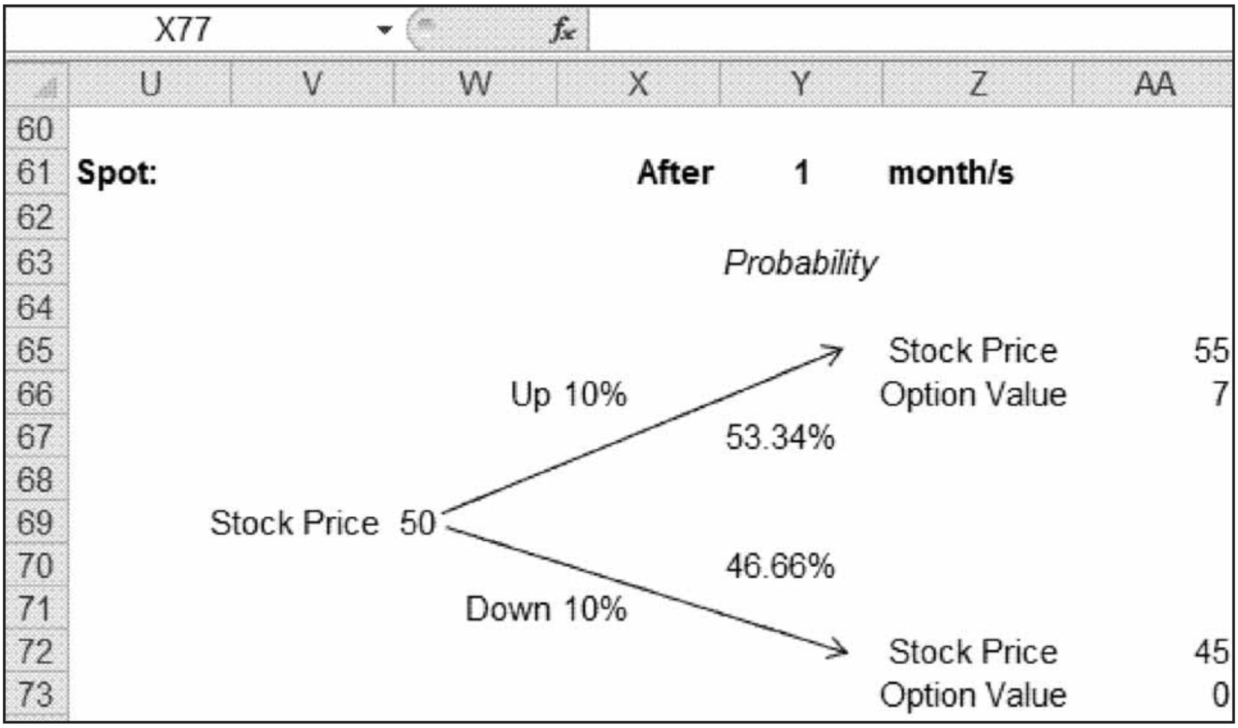
Rs. 50.33 ÷ $(2.71828^{(8\% \times 1 \div 12)})$

i.e. Rs. 50, which is the spot price.

The option with exercise price of Rs. 48 has value only if the stock price is higher. The option value is Rs. 55 – Rs. 48 i.e. Rs. 7, when the stock price is Rs. 55. It is worthless, when the stock price is lower at Rs. 45. The binomial tree is shown in Figure 3.1.

Figure 3.1

Binomial Chart – Single Period



The value of the option at the end of 1 month can be calculated to be Rs. 3.73, as shown in Table 3.2. The present value of the option is

Rs. 3.73 ÷ $e^{(8\% \times 1 \div 12)}$

i.e. Rs. 3.71.

Table 3.2

AA34 f_x =AA32+AA30

	U	V	W	X	Y	Z	AA
27							
28	1	2	3	4	5	Option Value (6)	7 = 5 X 6
29							
30		Up	10%	P*	53.34%	7	3.73
31							
32		Down	10%	1 - P*	46.66%	0	0.00
33							
34		Expected Value of Call Option in				1 month/s	3.73
35							

Between the two scenarios:

- The range of stock price is Rs. 55 – Rs. 45 i.e. Rs. 10.
- The range of option value is Rs. 7 – Rs. 0 i.e. Rs. 7.

The delta of the option is Rs. 7 ÷ Rs. 10 i.e. 0.70.

This means that the call option has the same exposure as holding 0.70 of the underlying share. Buying the option entails an outlay of Rs. 3.71.

Instead of the option, if you choose to buy 0.70 units of the share, the outlay would have been Rs. 50 X 0.70 i.e. Rs. 35.

Effectively, the option is providing financing of Rs. 35 – Rs. 3.71 i.e. Rs. 31.29 at 0.67% for 1 month.

Against this financing, the amount repayable at the end of 1 month would have been Rs. 31.29 X (1 + 0.67%) i.e. Rs. 31.50.

If the investor bought 0.7 shares with the financing mentioned above, then at the end of 1 month he will be left with the value of the share less the repayment of financing. This can be calculated for the two scenarios as follows:

- *Up 10%*

  (Rs. 55 X 0.70) – Rs. 31.50

  i.e. Rs. 7

- *Down 10%*

  (Rs. 45 X 0.70) – Rs. 31.50

  i.e. Rs. 0

The range of values is the same as in the case of purchase of 1 call option.

3.2 Multiple Period Binomial

Let us now extend the example for 1 more month, with the same assumptions regarding u, d, r and exercise price.

- In the first period (of one month) if the share has gone up from Rs. 50 to Rs. 55, then a further 10% up in the second period (of one more month) will take the share price up to Rs. 60.50, while 10% down will take the share price down to Rs. 49.50.
  - With the share price at Rs. 60.50, the value of the option with exercise price of Rs. 48 would be Rs. 60.50 – Rs. 48 i.e. Rs. 12.50.
  - With the share price at Rs. 49.50, the value of the option with exercise price of Rs. 48 would be Rs. 1.50.
  - The expected value of the option at the end of the second period would be (Rs. 12.50 X 53.34%) + (Rs. 1.50 X 46.66%) i.e. Rs. 7.37
  - Its value at the end of the first period would be

    Rs. 7.37 ÷ $e^{(8\% \times 1 \div 12)}$

    i.e. Rs. 7.32.
- In the first period if the share has gone down from Rs. 50 to Rs. 45, then in the second period, a 10% up will take the share price up to Rs. 49.50, while a further 10% down will take the share price down to Rs. 40.50.
  - With the share price at Rs. 49.50, the value of the option with exercise price of Rs. 48 would be Rs. 1.50.
  - With the share price at Rs. 40.50, the value of the option with exercise price of Rs. 48 would be Nil.
  - The expected value of the option at the end of the second period would therefore be (Rs. 1.50 X 53.34%) + (Rs. 0 X 46.66%) i.e. Rs. 0.80

- Its value at the end of the first period would be

  Rs. 0.80 ÷ $e^{(8\% \text{ X } 1 \div 12)}$

  i.e. Rs. 0.79.

- If we move backwards along the binomial chart shown in Figure 3.2, we can see that there are two branches (possibilities) in Period 1.

  - Option value of Rs. 7.32, which has a 53.34% probability.
  - Option value of Rs. 0.79, which is 46.66% probable.

  The expected value of the option at the end of the first period is

  (Rs. 7.32 X 53.34%) + (Rs. 0.79 X 46.66%)

  i.e. Rs. 4.28

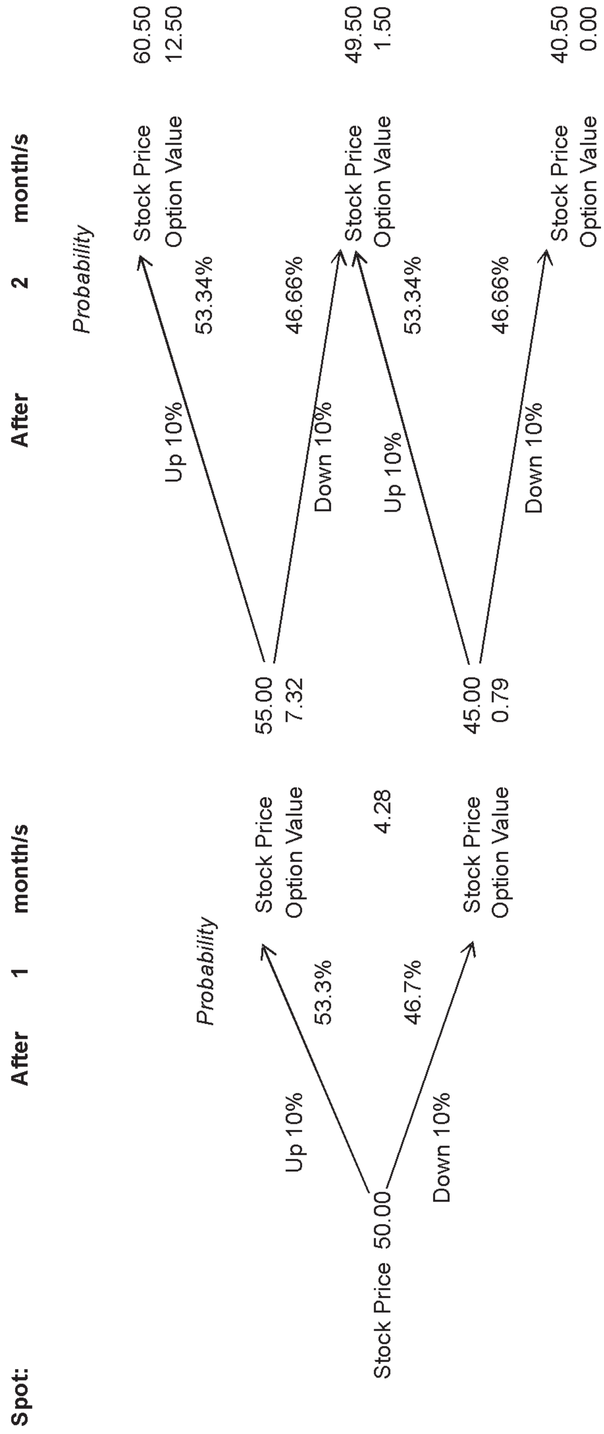
- The immediate value of the option would be

  Rs. 4.28 ÷ $e^{(8\% \text{ X } 1 \div 12)}$

  i.e. Rs. 3.93

Figure 3.2

Binomial Chart – Multiple Period



At time 0:

- The range of stock price is Rs. 55 – Rs. 45 i.e. Rs. 10.
- The range of option value is Rs. 7.32 – Rs. 0.79 i.e. Rs. 6.52.

The delta of the option is Rs. 6.52 ÷ Rs. 10 i.e. 0.652.

A delta hedge would therefore entail taking a long position of 0.652 shares of the underlying.

After 1 month, depending on how the stock price moves, there are two possible deltas, as follows:

- Stock up 10%
    - The range of stock price is Rs. 60.50 – Rs. 49.50 i.e. Rs. 11.
    - The range of option value is Rs. 12.50 – Rs. 1.50 i.e. Rs. 11.
    - Delta = Rs. 11 ÷ Rs. 11 i.e. 1.
- Stock down 10%
    - The range of stock price is Rs. 49.50 – Rs. 40.50 i.e. Rs. 9.
    - The range of option value is Rs. 1.50 – Rs. 0.0 i.e. Rs. 1.50.
    - Delta = Rs. 1.50 ÷ Rs. 9 i.e. 0.167.

When the share price went up, the delta also went up from 0.652 to 1. Thus, more shares need to be purchased for a delta hedge.

When the share price went down, the delta went down from 0.652 to 0.167. Shares need to be sold to maintain the delta hedge.

Delta hedge thus entails buying shares in a rising market, and selling them in a falling market. It is for this reason that dynamic hedging can be costly.

In the calculated example, we have valued the 2-month contract, on the basis of 2 steps of 1 month each. More the number of steps that we use, finer would be the approximation of option value. However, this also increases the computational complexity. It is for this reason that traders use software to determine option values.

3.3 European Put Option

The call option had value, when the stock price was higher than the exercise price; it was worthless, when the stock price was lower than the exercise price.

The position gets reversed, if it is a put option, as shown in Figure 3.3. The value of the option at the end of 1 month, can be calculated to be

(Rs. 0 X 53.34%) + (Rs. 3 X 46.66%)

i.e. Rs. 1.40

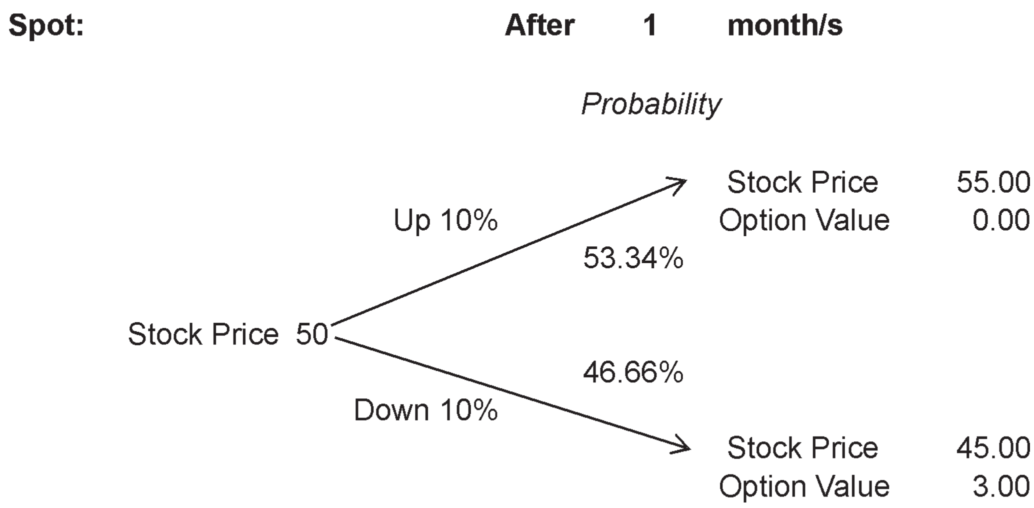
Its immediate value is calculated to be

Rs. 1.40 ÷ $e^{(8\% \times 1 \div 12)}$

i.e. Rs. 1.39

Figure 3.3

Binomial Chart for Put Option with Exercise Price of Rs. 48



- Delta can be calculated as follows:
  - The range of stock price is Rs. 55 – Rs. 45 i.e. Rs. 10.
  - The range of option value is Rs. 0 – Rs. 3 i.e. - Rs. 3.
  - Delta = - Rs. 3 ÷ Rs. 10 i.e. -0.30

The negative sign indicates that a delta hedge would entail short-selling 0.30 units of the underlying.

- An investor's transactions for writing the put and doing the delta hedge can be detailed as follows:
  - For writing the put, option premium will be received. The value was calculated to be Rs. 1.39
  - On short-selling the 0.30 units of the underlying, an amount of 0.30 X Rs. 50 i.e. Rs. 15 will be received
  - An amount of Rs. 1.39 + Rs. 15 i.e. Rs. 16.39 is available for investment at the risk-free rate of 0.67% for 1 month. On maturity, this will translate to Rs. 16.39 X (1+0.67%) i.e. Rs. 16.50.

- After 1 month, if share prices go down to Rs. 45, the counter party will exercise the option to offer the share at Rs. 48. A payment of Rs. 48 needs to be made. This will come out of:
- Rs. 16.50 maturity value calculated earlier
- Out of the 1 share received, 0.3 will go to cover the short-sold position. The balance 0.7 will be sold at the prevailing market price of Rs. 45 per share, to realise Rs. 31.50.

Rs. 16.50 + Rs. 31.50 = Rs. 48.00, which is payable to the option buyer.

- If share price goes up to Rs. 55, the counter party will not exercise the option to offer the share at Rs. 48. 0.3 units of the share will need to be bought to cover the short-sold position. The purchase will have to be at the prevailing market price of Rs. 55. This will call for funds of Rs. 55 X 0.3 i.e. Rs. 16.50, which is the maturity value already available.

3.4 Binomial Model for American Options

While a European option is only exercisable at the end of the contract, an American option is exercisable at any stage in between. Therefore, on maturity, there is essentially no difference between the two kinds of options. Before maturity, however, their value can differ.

In the call option discussed earlier (Figure 3.2), when stock price was down 10%, the option value of 0.79 at the end of 1 month was arrived at on the basis of the two branches to its right (option value =1.5 and option value = 0, which pertained to the end of 2 months). The prevailing market price of the stock (at the end of 1 month) was not considered in the calculation, because, it was a European option (and hence, not exercisable before maturity).

If it were an American option, then the investor would have a choice to hold it as an option or exercise the option, on any day upto maturity.

- At the end of 1 month, if he were to hold it as an option, then the earlier calculated value of 0.79 would hold.
- What is its value if it were exercised? Since the market price of Rs. 45 is below the exercise price of Rs. 48, the investor will not exercise it. Value based on exercise is therefore zero.

If the market price had been higher than the exercise price to the extent of more than Rs. 0.79, then the value based on exercise would have been used in the option value calculations, instead of 0.79.

Let us perform a similar check for the other node (stock price was up 10%) at the end of

1 month, where the option value was determined to be Rs. 7.32. This calculated value was based on the option nodes to its right, viz. option values of Rs. 12.50 and Rs. 1.50 at the end of 2 months.

If it were an American option, then the investor would either keep it as an option, or exercise it. Therefore, the value of the option at the end of 1 month would be the higher of the following values:

- Value based on keeping it as an option, calculated to be Rs. 7.32.
- Value based on exercising the option, which is Rs. 55 – Rs. 48 i.e. Rs. 7.00.

The latter value being lower, Rs. 7.32 would be he value. If, however, the market price was higher than the exercise price by more than Rs. 7.32 at the end of 1 month, then (instead of Rs. 7.32) that difference between market price and exercise price would have been used for the calculations to determine value of the option at the beginning of the contract. Accordingly, the value of the American option would have been higher than the Rs. 3.93 calculated earlier for the European option.

Thus, the binomial model is capable of valuing both European and American options.

3.5 Role of Volatility in 'u' and 'd'

In the calculations so far, we set the price change at 10% up or down. Accordingly, 'u' was 1.1 and 'd' was 0.9.

While constructing the binomial tree, 'u' and 'd' are determined based on Volatility (σ), as follows:

$u = e^{\sigma\sqrt{T}}$

$d = e^{-\sigma\sqrt{T}}$i.e. $1 \div u$

So far, we have taken T as 1÷ 12. Suppose σ is 20%.

Substitution, we get

$u = 2.71828^{(20\% \times \sqrt{(1\div 12)}}$

i.e. 1.0593

d = 1 ÷ 1.0593

i.e. 0.9439

We assumed risk-free rate R to be 8%. Accordingly, the probability P* would have been calculated as:

$(e^{rT} - d) \div (u - d)$

i.e. $(2.71828^{(8\% \times 1\div 12)} - 0.9439) \div (1.0593 - 0.9439)$

i.e. 54.35%

Points to remember

- The binomial model assumes that in a short period of time a stock can take either of two prices – one higher and one lower than the current stock price. The binomial tree built on this basis can be used to value various options.
- If 'p*' is the probability of the share going up, then '1-p*' is the probability of it going down. In a risk-neutral environment, with continuous compounding, the value of 'p*' can be calculated to be:

  $(e^{rT} - d) \div (u - d)$

- Delta of an option indicates its equivalent position in terms of number of shares. Delta of a call option is positive; that of a put option is negative. Thus, the hedge for writing a call option would be to buy the delta number of shares; hedge for writing a put option would be to short-sell the delta number of shares.
- Binomial pricing can be applied for a single period or multiple periods. More the number of periods, finer the option pricing. But the calculations get complicated with each additional period.
- Delta hedge entails buying shares in a rising market, and selling them in a falling market. It is for this reason that dynamic hedging can be costly.
- The call option has value, when the stock price is higher than the exercise price; it is worthless, when the stock price is lower than the exercise price. The position gets reversed, if it is a put option i.e. it has value if the stock price is lower than the exercise price.
- While a European option is only exercisable at the end of the contract, an American option is exercisable at any stage in between. Therefore, on maturity, there is essentially no difference between the two kinds of options. Before maturity, however, their value can differ.
- While constructing the binomial tree, 'u' and 'd' are determined based on Volatility (σ), as follows:

  $u = e^{\sigma\sqrt{T}}$

  $d = e^{-\sigma\sqrt{T}}$ i.e. $1 \div u$

Self-Assessment Questions

- Binomial model assumes that over a short period of time, a stock can take either of two prices, which may be higher or lower than the current price.
  - True
  - **False**
- Which of the following is true?
  - Delta of a call option is positive
  - Delta of a put option is negative
  - **Both the above**
  - None of the above
- Delta hedging can be costly because:
  - Option premia are higher for delta hedges as compared to regular trading
  - Exchange imposes additional margins for delta hedges
  - Risk-free rate to be used is higher
  - **Delta hedge entails buying shares in a rising market, and selling them in a falling market**
- On maturity, there is no difference in valuation of European and American options.
  - **True**
  - False
- Binomial model of option pricing can be used in which of the following cases
  - European Call
  - European Put
  - American Call
  - **All the above**

Chapter 4: Black - Scholes Option Pricing Model

4.1 European Call Option

The price of a European call option on a non-dividend paying stock is calculated as follows:

$C = S_0N(d_1) - Ke^{-rT}N(d_2)$

Where,

C stands for Call option

$S_0$is the current price of the stock i.e. in time = 0

N (x) denotes the cumulative probability distribution function for a standardised normal distribution (mean = 0, standard deviation = 1). Excel function NORM.S.DIST(X,True) is used to arrive at the value.

K is the exercise price

e = 2.71828

r is the continuously compounded risk-free rate

T is the time to maturity of the option

d_1 is defined to be $\dfrac{\ln(S_0 \div K) + (r + \sigma^2 \div 2)T}{\sigma\sqrt{T}}$

d_2 is defined to be $\dfrac{\ln(S_0 \div K) + (r - \sigma^2 \div 2)T}{\sigma\sqrt{T}}$

σ is the annual volatility of the stock price

Example 4.1

Suppose a stock, trading at Rs. 20, has volatility of 15% p.a. A 3-month option on that stock has exercise price of Rs. 17. Risk-free rate is 8% p.a. What would be its price if it is an European Call?

S_0= Rs. 20

K = Rs. 17

e = 2.71828

r = 8%

T = 3 ÷ 12 i.e. 0.25

σ = 0.15

$$d_1 = \frac{\ln(20 \div 17) + (0.08 + 0.15^2 \div 2) \times 0.25}{0.15\sqrt{0.25}} \text{ i.e. } 2.4711$$

$$d_2 = \frac{\ln(20 \div 17) + (0.08 - 0.15^2 \div 2) \times 0.25}{0.15\sqrt{0.25}} \text{ i.e. } 2.3961$$

Ke^{-rt} = 17 X $2.71828^{-0.08 \text{ X } 0.25}$i.e. 16.6634

$N(d_1)$ = NORM.S.DIST(2.4711,TRUE) = 0.9933

$N(d_2)$ = NORM.S.DIST(2.3961,TRUE) = 0.9917

The price of a Call is $S_0N(d_1) - Ke^{-rT}N(d_2)$

Substituting, we get (20 X 0.9933) – (16.6634 X 0.9917)

i.e. Rs. 3.34

The price of the call is Rs. 3.34.

The total acquisition cost of a share on exercise of call would be Rs. 3.34 (call premium) + Rs. 17 (exercise price) i.e. Rs. 20.34.

Thus, from the current price of Rs. 20, if the stock goes up by more than Rs.0.34, the buyer of the call option will break even (ignoring interest cost on call premium paid).

4.2 European Put Option

The price of a European put option on a non-dividend paying stock is calculated as follows:

$P = Ke^{-rT}N(-d_2) - S_0N(-d_1)$

Example 4.2

What is the value of European put for the same numbers as Example 4.1?

$N(-d_1)$ = NORM.S.DIST(-2.4711,TRUE) = 0.0067

$N(-d_2)$ = NORM.S.DIST(-2.3961,TRUE) = 0.0083

Substituting, we get P = (16.6634 X 0.0083) – (20 X 0.0067)

i.e. Rs. 0.0034 (negligible).

4.3 Dividends

Suppose the continuous dividend yield on a stock is q, the Black Scholes formulae can be revised as follows:

- $d_1 = \dfrac{\ln(S_0 \div K) + (r - q + \sigma^2 \div 2)T}{\sigma\sqrt{T}}$
- $d_2 = \dfrac{\ln(S_0 \div K) + (r - q - \sigma^2 \div 2)T}{\sigma\sqrt{T}}$

- $C = S_0e^{-qt}N(d_1) - Ke^{-rT}N(d_2)$
- $P = Ke^{-rT}N(-d_2) - S_0e^{-qt}N(-d_1)$

<u>Example 4.3</u>

What is the value of European Call and Put for the same numbers as Example 4.1, if the continuous dividend yield is 2%?

q = 2%

$d_1 = \frac{\ln(20 \div 17) + (0.08 - 0.02 + 0.15^2 \div 2) \times 0.25}{0.15\sqrt{0.25}}$ i.e. 2.4044

$d_2 = \frac{\ln(20 \div 17) + (0.08 - 0.02 - 0.15^2 \div 2) \times 0.25}{0.15\sqrt{0.25}}$ i.e. 2.3294

$e^{-qt} = 2.71828^{-0.02 \text{ X } 0.25}$ i.e. 0.9950

$N(d_1)$ = NORM.S.DIST(2.4044,TRUE) = 0.9919

$N(d_2)$ = NORM.S.DIST(2.3294,TRUE) = 0.9901

The price of an European Call is $S_0e^{-qt}N(d_1) - Ke^{-rT}N(d_2)$

Substituting, we get (20 X 0.9950X 0.9919) – (16.6634 X 0.9901)

i.e. Rs. 3.24

The price of the call is Rs. 3.24.

$N(-d_1)$ = NORM.S.DIST(-2.4044,TRUE) = 0.0081

$N(-d_2)$ = NORM.S.DIST(-2.3294,TRUE) = 0.0099

The price of an European Put is $Ke^{-rT}N(-d_2) - S_0e^{-qt}N(-d_1)$

Substituting, we get P = (16.6634 X 0.0099) – (20 X 0.9950 X 0.0081)

i.e. Rs. 0.0041 (negligible).

4.4 American Options

On maturity, there is no difference between an American Option and an European Option. However, an American Option can be exercised before maturity; an European Option cannot be so exercised before maturity.

The benefit of keeping an option position open is the insurance it offers to the portfolio. This will be lost, if the option is exercised. This is a significant reason why an option may not be exercised. The position regarding exercise varies between call and put options.

Exercise of a call option would entail an immediate payment of exercise price. Therefore, it does not make sense for a trader to exercise the call option, so long as no dividend is payable on the stock. It would be better to sell the call option with a gain if it is in the money.

Only if a large dividend is expected on the stock during the life of an option, it may be worthwhile to exercise the call option. Therefore, in most cases, Black Scholes can be applied even for American call options.

Exercise of a put option leads to immediate receipt of money. Therefore, put options are more likely to be exercised, particularly when they are deep in the money. In such cases, the trader may choose to value based on the binomial model which is more cumbersome, or live with the inaccuracy of the Black Scholes model. If the Black Scholes value turns out to be lower than the intrinsic value, then they use the intrinsic value.

After a dividend is paid, the stock price corrects itself. This makes the put more valuable. Therefore, unlike with call options, put options may not be exercised if a dividend is expected. In this situation again, Black Scholes can be applied.

Points to remember

- The price of a European call option on a non-dividend paying stock is calculated as $C = S_0N(d_1) - Ke^{-rT}N(d_2)$

  Where,

  - C stands for Call option
  - S_0 is the current price of the stock i.e. in time = 0
  - N (x) denotes the cumulative probability distribution function for a standardised normal distribution (mean = 0, standard deviation = 1). Excel function NORM.S.DIST(X,True) is used to arrive at the value.
  - K is the exercise price
  - e = 2.71828
  - r is the continuously compounded risk-free rate
  - T is the time to maturity of the option
  - d_1 is defined to be $\frac{\text{In}(S_0 \div K) + (r + \sigma^2 \div 2)T}{\sigma\sqrt{T}}$
  - d_2 is defined to be $\frac{\text{In}(S_0 \div K) + (r - \sigma^2 \div 2)T}{\sigma\sqrt{T}}$
  - σ is the annual volatility of the stock price
- The price of a European put option on a non-dividend paying stock is calculated as $P = Ke^{-rT}N(-d_2) - S_0N(-d_1)$
- For a stock paying continuous dividend yield of q, the formulae can be revised as follows:

- o $d_1 = \dfrac{\text{In}(S_0 \div K) + (r - q + \sigma^2 \div 2)T}{\sigma\sqrt{T}}$
- o $d_2 = \dfrac{\text{In}(S_0 \div K) + (r - q - \sigma^2 \div 2)T}{\sigma\sqrt{T}}$
- o $C = S_0e^{-qt}N(d_1) - Ke^{-rT}N(d_2)$
- o $P = Ke^{-rT}N(-d_2) - S_0e^{-qt}N(-d_1)$

- On maturity, there is no difference between an American Option and an European Option. However, an American Option can be exercised before maturity; an European Option cannot.
- The benefit of keeping an option position open is the insurance it offers to the portfolio. This will be lost, if the option is exercised. This is a significant reason why an option may not be exercised. The position regarding exercise varies between call and put options.
- Exercise of a call option would entail an immediate payment of exercise price. Therefore, it does not make sense for a trader to exercise the call option, so long as no dividend is payable on the stock. It would be better to sell the call option with a gain if it is in the money.
- Only if a large dividend is expected on the stock during the life of an option, it may be worthwhile to exercise the call option. Therefore, in most cases, Black Scholes can be applied even for American call options.
- Exercise of a put option leads to immediate receipt of money. Therefore, put options are more likely to be exercised, particularly when they are deep in the money. In such cases, the trader may choose to value based on the binomial model which is more cumbersome, or live with the inaccuracy of the Black Scholes model. If the Black Scholes value turns out to be lower than the intrinsic value, then they use the intrinsic value.
- After a dividend is paid, the stock price corrects itself. This makes the put more valuable. Therefore, unlike with call options, put options may not be exercised if a dividend is expected. In this situation again, Black Scholes can be applied.

Self-Assessment Questions

❖ Suppose a stock, trading at Rs. 60, has volatility of 25% p.a. A 1-month option on that stock has exercise price of Rs. 58. Risk-free rate is 6% p.a. What would be its price if it is an European Call?

- ➢ **Rs. 3.08**
- ➢ Rs. 3.03
- ➢ Rs. 2.97
- ➢ Rs. 2.93

- Suppose a stock, trading at Rs. 60, has volatility of 25% p.a. A 1-month option on that stock has exercise price of Rs. 58. Risk-free rate is 6% p.a. What would be its price if it is an European Put?
  - **Rs. 0.79**
  - Rs. 0.83
  - Rs. 1.02
  - Rs. 0.93
- Suppose a stock, trading at Rs. 60, has volatility of 25% p.a. A 1-month option on that stock has exercise price of Rs. 58. Risk-free rate is 6% p.a. The continuous dividend yield on the stock is 3%. What would be its price if it is an European Call?
  - Rs. 3.08
  - Rs. 3.03
  - **Rs. 2.97**
  - Rs. 2.93
- Suppose a stock, trading at Rs. 60, has volatility of 25% p.a. A 1-month option on that stock has exercise price of Rs. 58. Risk-free rate is 6% p.a. The continuous dividend yield on the stock is 3%. What would be its price if it is an European Put?
  - Rs. 0.79
  - **Rs. 0.83**
  - Rs. 1.02
  - Rs. 0.93

Chapter 5: Option Greeks

Knowledge of options in the Black Scholes framework is incomplete without understanding the Greeks, which show the sensitivity of the value of an option to various parameters.

5.1 Delta

Delta is a measure of sensitivity of the value of an option to its stock price. This was discussed in Chapter 3, where it was shown that Delta of an option indicates its equivalent position in terms of number of shares. This is the basis for delta hedging of portfolios.

1. European Call on non-dividend paying stock

Δ of call = $N(d_1)$

Where,

d_1 is defined to be $\dfrac{\ln(S_0 \div K) + (r + \sigma^2 \div 2)T}{\sigma\sqrt{T}}$

N (x) denotes the cumulative probability distribution function for a standardised normal distribution (mean = 0, standard deviation = 1). Excel function NORM.S.DIST(X,True) is used to arrive at the value.

Example 5.1

Let us consider the same option that was discussed in Example 4.1 viz. A stock, trading at Rs. 20, has volatility of 15% p.a. A 3-month option on that stock has exercise price of Rs. 17. Risk-free rate is 8% p.a.

Substituting the values in the above formula, Δ of the call is 0.9933.

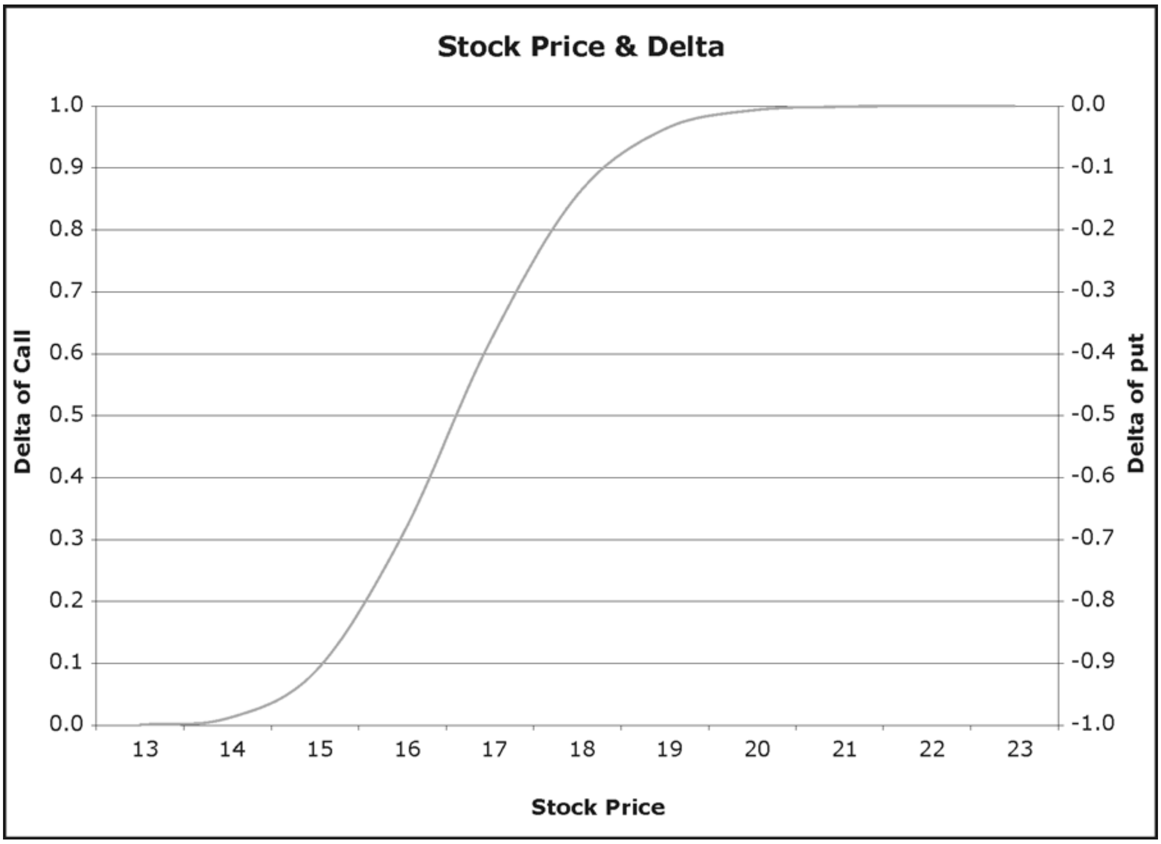
Delta varies with the stock price. The relation between delta and stock price for this option is shown in Figure 5.1. The Y-axis on the left of the graph shows the value of call delta at different values of the stock price.

The stock is trading at Rs. 20, while the call option is deep in the money at the exercise price of Rs. 17.

- As the call option goes deeper in the money (stock price significantly above Rs. 17), its delta gets closer to 1.
- When the call option goes deeper out of the money (stock price significantly below Rs. 17), its delta gets closer to 0.
- When the stock price is closer to the exercise price, the delta of the call option is closer to 0.5.

Figure 5.1

Relation between Stock Price and Delta



2. European Put on non-dividend paying stock

Δ of put = $N(d_1) - 1$

For example 5.1, it can be calculated to be -0.0067.

The secondary Y axis on the right of the graph in Figure 5.1 shows the value of Delta of put for various values of the stock price. The put delta has the same shape as the call delta. However, note that the put delta values range from -1 to 0 (instead of 0 to 1 for the call delta values).

- As the put option goes deeper in the money (stock price significantly below Rs. 17), its delta gets closer to -1.
- When the put option goes deeper out of the money (stock price significantly above Rs. 17), its delta gets closer to 0.
- When the stock price is closer to the exercise price, the delta of the put option is closer to -0.5.

3. European Call on asset paying a yield of q

Δ of call = $e^{-qT} N(d_1)$

In example 5.1, if we assume the continuous dividend on the stock at 2%, delta of the call can be computed to be 0.9883.

4. European Put on asset paying a yield of q

Δ of put = $e^{-qT} [N(d_1) - 1]$

In the above example, it can be calculated as -0.0067

5.2 Gamma

Gamma measures the rate of change of delta as the stock price changes. It is an indicater of the benefit for the option holder (and problem for the option seller) on account of fluctuations in the stock price.

As seen Figure 5.1, the delta of call and delta of put on the same option have the same shape. Therefore, the rate of change, viz. Gamma is the same for both call and put options.

5. European Call / Put on non-dividend paying stock

$$\Theta = \frac{N'(d1)}{S_0 \sigma \sqrt{T}}$$

Where,

$$N'(x) = \frac{1}{\sqrt{2\pi}} e^{-x2/2}$$

(N'(x) denotes the normal density function)

$$\pi = \frac{22}{7}$$

For example 5.1, the values can be substituted in the above formula to arrive at the Gamma value of 0.0126.

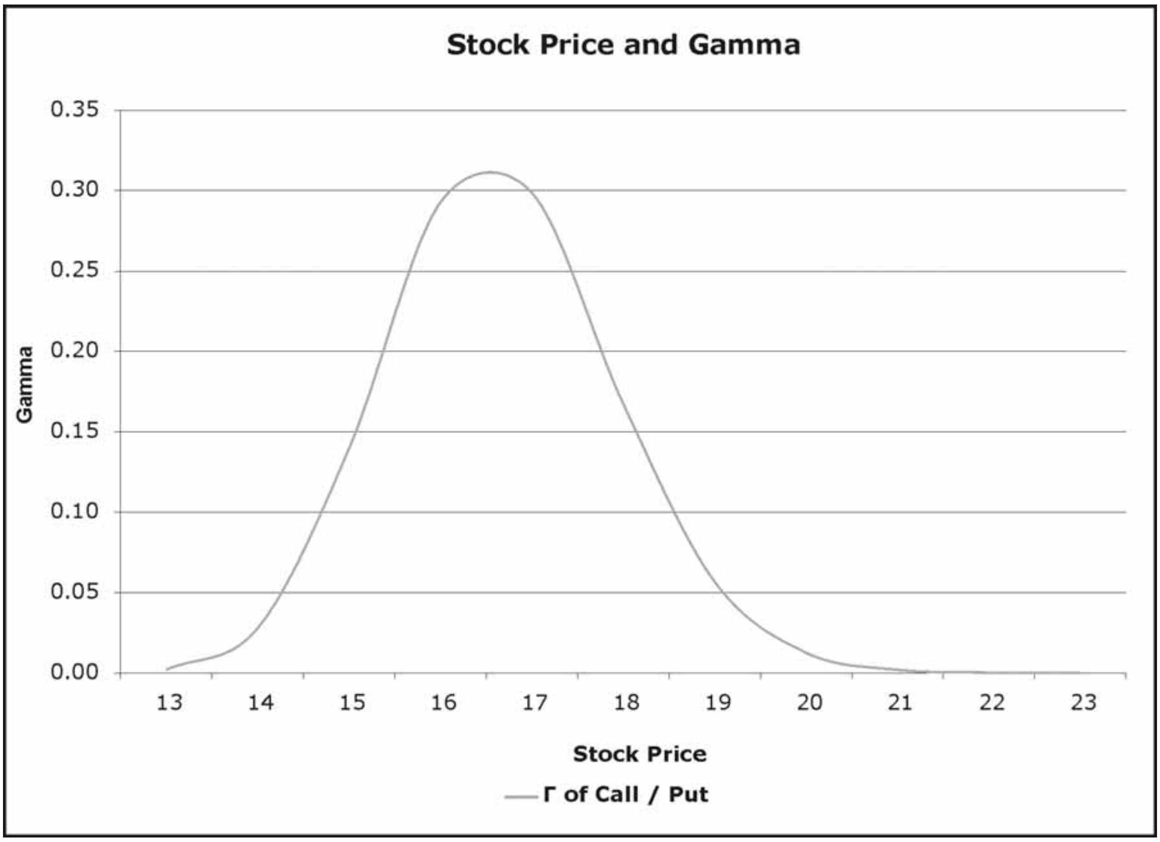
The movement in gamma of the option mentioned in Example 5.1, as the stock price changes can be seen in Figure 5.2.

Gamma is high when the option is at the money. However, it declines as the option goes deep in the money or out of the money.

The graph looks like the normal distribution bell-shaped curve, though it is not symmetrical. The longer extension on the right side implies that for the same difference between stock price and exercise price, in the money calls (and out of the money puts) have higher gamma than out of the money calls (and in the money puts)

Figure 5.2

Relation between Stock Price and Gamma



6. European Call / Put on asset paying a yield of q

$$\Theta = \frac{N'(d1)e^{-qT}}{S_0\sigma\sqrt{T}}$$

For example 5.1, taking continuous dividend at 2%, the Gamma value can be calculated as 0.0125.

5.3 Theta

With the passage of time, the option gets closer to maturity. Theta is the sensitivity of the value of the option with respect to change in time to maturity (assuming everything else remains the same).

7. European Call on non-dividend paying stock

$$\Theta = \frac{S_0N'(d1)\sigma}{2\sqrt{T}} - rKe^{-rT}N(d_2)$$

Where,

d_2 is defined to be $\frac{\ln(S_0 \div K) + (r - \sigma^2 \div 2)T}{\sigma\sqrt{T}}$

Substituting the values from Example 5.1, it is calculated to be -1.3785. Per day value of

Theta (which is more meaningful) is calculated by dividing by 365. The value is -0.0038.

Thetais usually negative, because shorter the time to maturity, lower the value of the option.

8. European Put on non-dividend paying stock

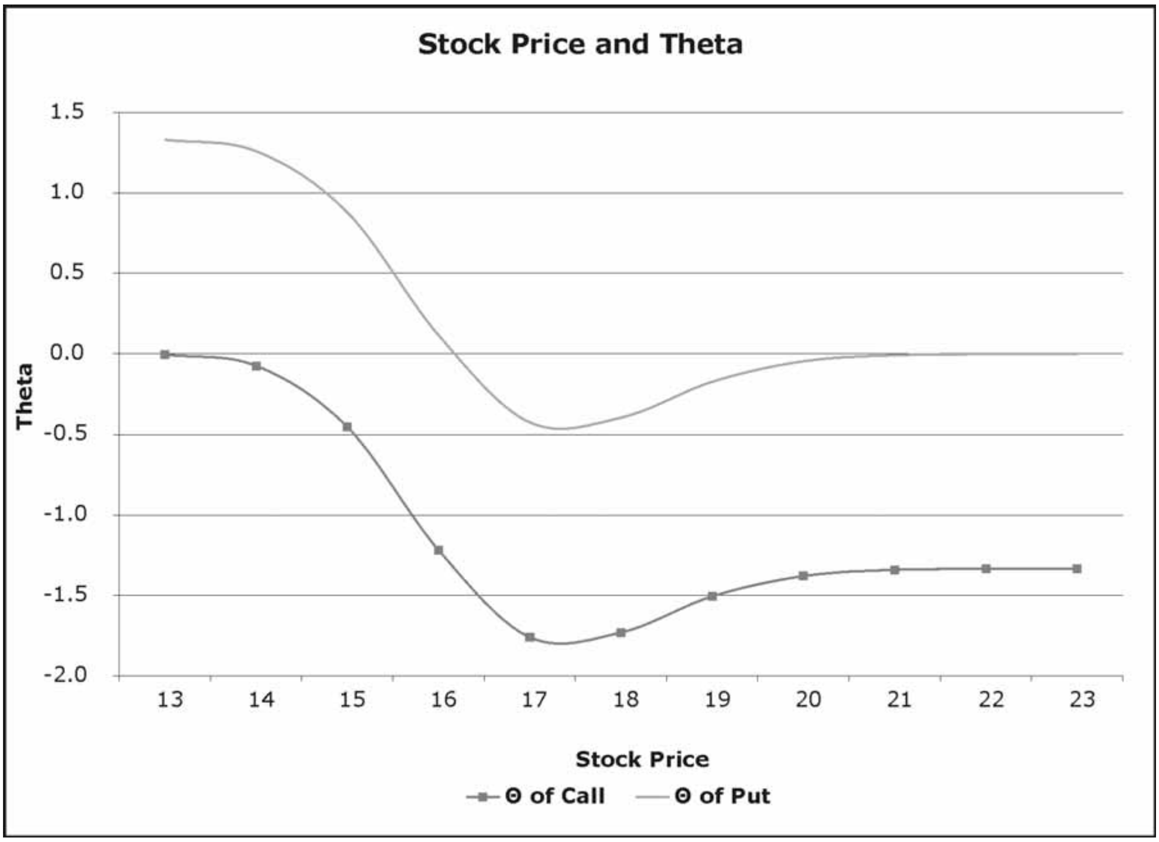
$$\Theta = \frac{S_0 N'(d1)\sigma}{2\sqrt{T}} + rKe^{-rT}N(-d_2)$$

Substituting the values from Example 5.1, it is calculated to be -0.0455. Per day value of Theta is -0.0001.

Change in value of Theta of both call and put options as the stock price changes can be seen in Figure 5.3.

Figure 5.3

Relation between Stock Price and Theta



9. European Call on asset paying yield of q

$$\Theta = \frac{S_0 N'(d1)\sigma}{2\sqrt{T}} + rKe^{-rT}N(-d_2)$$

Taking compounded dividend at 2%, the theta in the case of Example 5.1 works out to -0.9829.

Call on a dividend paying stock can have a positive theta.

10. European Put on asset paying yield of q

$$\Theta = \frac{S_0 N'(d1)\sigma e^{-qT}}{2\sqrt{T}} + qS_0 N(-d_1)e^{-qT} + rKe^{-rT}N(-d_2)$$

Taking compounded dividend at 2%, the theta in the case of Example 5.1 works out to -0.0479.

5.4 Vega

Vega measures the change in option value when the volatility of the stock changes. The call and put options have the same Vega.

11. European Call / Put on non-dividend paying stock

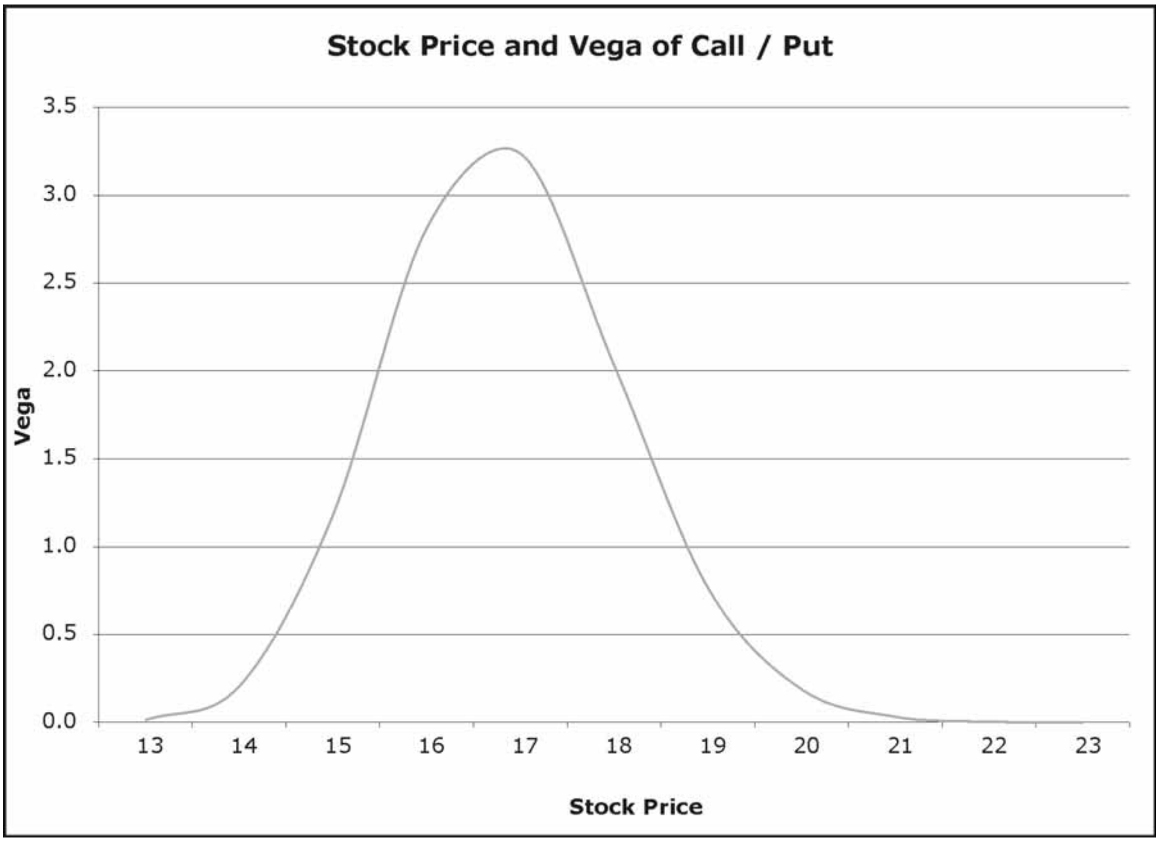
$V = S_0\sqrt{T}\, N'(d_1)$

In the case of Example 5.1, it works out to 0.1883.

The change in Vega for different values of the stock price for the option in Example 5.1 is shown in Figure 5.4

Figure 5.4

Relation between Stock Price & Vega



As with gamma, it looks like an asymmetric bell-shaped curve. Vega is maximum around the exercise price.

12. European Call / Put on asset paying yield of q

$V = S_0\sqrt{T}\, N'(d_1)\, e^{-qT}$

In Example 5.1, with continuous dividend of 2%, the calculated value is 0.1874.

5.5 Rho

Rho measures the sensitivity of the value of an option to changes in the risk free rate.

13. European Call on non-dividend paying stock

$\rho = KTe^{-rT}N(d_2)$

In the case of Example 5.1, the calculated value is 4.1313.

14. European Put on non-dividend paying stock

$\rho = -KTe^{-rT}N(-d_2)$

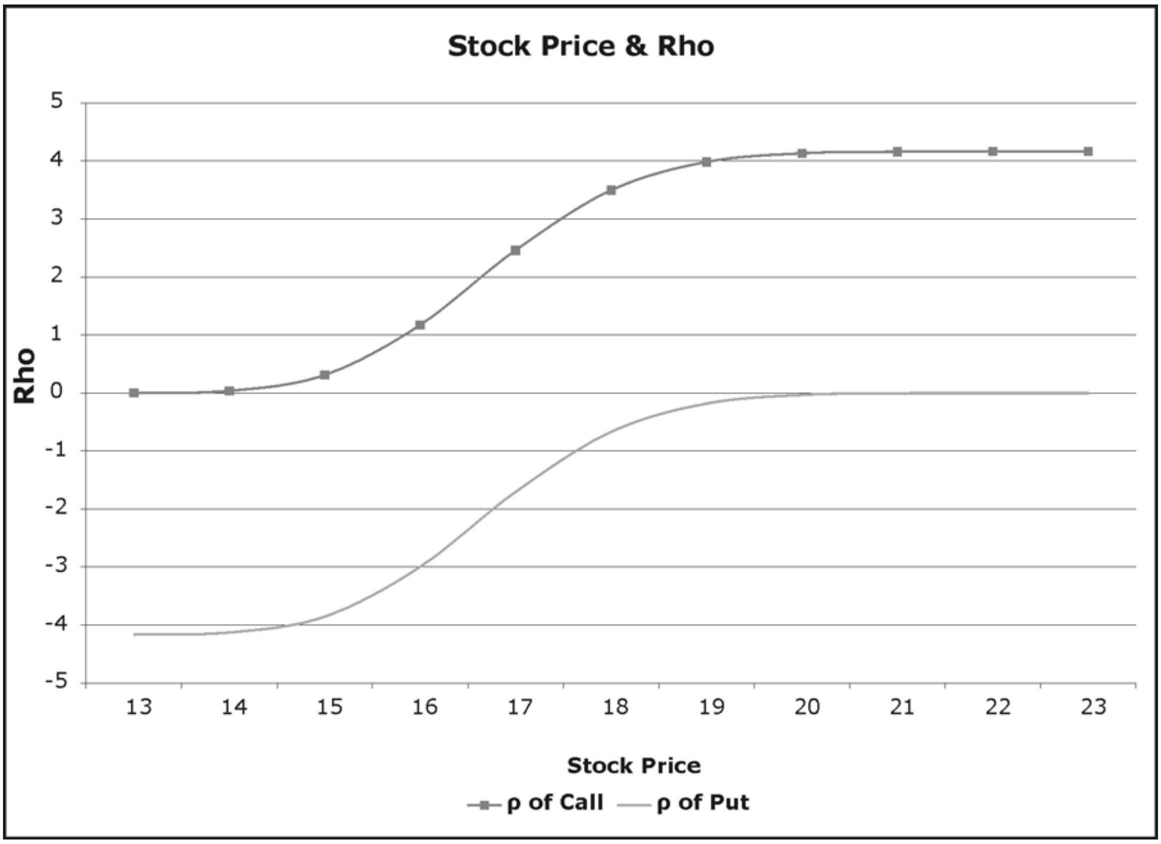
The calculated value is -0.0345 for Example 5.1.

The same formulae can be used even in the case of a dividend-paying stock.

Figure 5.5 shows how Rho of call and put options changes with the stock price.

Figure 5.5

Relation of Stock Price and Rho



Points to remember

- Delta is a measure of sensitivity of the value of an option to its stock price.
- Δ of an European call on a non-dividend paying stock = $N(d_1)$

  Where,

  - o d_1 is defined to be $\dfrac{\ln(S_0 \div K) + (r + \sigma^2 \div 2)T}{\sigma\sqrt{T}}$
  - o N (x) denotes the cumulative probability distribution function for a standardised normal distribution (mean = 0, standard deviation = 1). Excel function NORM.S.DIST(X,True) is used to arrive at the value.
- As the call option goes deeper in the money, its delta gets closer to 1. When the call option goes deeper out of the money, its delta gets closer to 0. When the stock price is closer to the exercise price, the delta of the call option is closer to 0.5.
- Δ of an European put on a non-dividend paying stock = $N(d_1) - 1$
- The put delta has the same shape as the call delta. However, its value ranges from -1 to 0 (instead of 0 to 1 for the call delta values).
- As the put option goes deeper in the money, its delta gets closer to -1. When the put option goes deeper out of the money (stock price significantly above Rs. 17), its delta gets closer to 0. When the stock price is closer to the exercise price, the delta of the put option is closer to -0.5.
- Δ of an European Call on asset paying a yield of q = $e^{-qT} N(d_1)$
- Δ of an European Put on asset paying a yield of q = $e^{-qT} [N(d_1) - 1]$
- Gamma measures the rate of change of delta as the stock price changes. It is an indicater of the benefit for the option holder (and problem for the option seller) on account of fluctuations in the stock price.
- The delta of call and delta of put on the same option have the same shape. Therefore, the rate of change, viz. Gamma is the same for both call and put options.
- Γ of an European Call / Put on a non-dividend paying stock = $\dfrac{N'(d1)}{S_0\sigma\sqrt{T}}$
- Γ of an European Call / Put on a stock paying dividend yield of q = $\dfrac{N'(d1)e^{-qT}}{S_0\sigma\sqrt{T}}$
- Theta is the sensitivity of the value of the option with respect to change in time to maturity.
- Θ of an European Call on a non-dividend paying stock =

  $-\dfrac{S_0 N'(d1)\sigma}{2\sqrt{T}} - rKe^{-rT}N(d_2)$

- Theta is usually negative, because shorter the time to maturity, lower the value of the option. However, Call on a dividend paying stock can have a positive theta.
- Θ of an European Put on a non-dividend paying stock =
  $-\frac{S_0 N'(d1)\sigma}{2\sqrt{T}} + rKe^{-rT}N(-d_2)$
- Θ of an European Call on an asset yielding dividend of q =
  $\frac{S_0 N'(d1)\sigma e^{-qT}}{2\sqrt{T}} + qS_0N(d_1)e^{-qT} - rKe^{-rT}N(d_2)$
- Θ of an European Put on an asset yielding dividend of q =
  $\frac{S_0 N'(d1)\sigma e^{-qT}}{2\sqrt{T}} - qS_0N(-d_1)e^{-qT} + rKe^{-rT}N(-d_2)$
- Vega measures the change in option value when the volatility of the stock changes. The call and put options have the same Vega.
- Vof an European Call / Put on a non-dividend paying stock = $S_0\sqrt{T}\,N'(d_1)$
- Vof an European Call / Put on an asset yielding dividend of q =

  $S_0\sqrt{T}\,N'(d_1)\,e^{-qT}$
- Rho measures the sensitivity of the value of an option to changes in the risk free rate.
- ρ of an European Call = $KTe^{-rT}N(d_2)$
- ρ of an European Put = $-KTe^{-rT}N(-d_2)$

Self-Assessment Questions

❖ __________ is a measure of sensitivity of the value of an option to its stock price.

  ➢ **Delta**

  ➢ Theta

  ➢ Gamma

  ➢ Rho

❖ As the call option goes deeper in the money, its delta gets closer to __________

  ➢ 0

  ➢ -1

  ➢ **1**

  ➢ Infinity

- Other things remaining the same, Gamma is the same for both call and put contracts
    - **True**
    - False
- Call on a dividend paying stock can have a positive theta.
    - **True**
    - False
- Other things remaining the same, Vega is the same for both call and put contracts
    - **True**
    - False
- __________ is a measure of sensitivity of the value of an option to risk-free rate.
    - Delta
    - Theta
    - Gamma
    - **Rho**

Chapter 6: Volatility

The concept of volatility was introduced in Chapter 2. Volatility of a stock is a measure of the uncertainty of the annual returns provided by it. The concept can be extended to any asset.

The application of volatility in pricing options was discussed in the subsequent chapters. It is important to understand the various facets of volatility.

6.1 Historical Volatility (σ)

More the data points, better the estimate of historical volatility. A thumb rule is to have as many days' return data as the number of days to which the volatility is to be applied. For example, the most recent 180 days' returns data is used for valuing a 6-month product; most recent 90 days' returns data is used for valuing a 3-month product. As an illustration, we use 15 days' returns in Table 6.1.

Table 6.1

Calculation of Volatility

Day	**Stock Price (Rs.)**	**Price Factor**	**Daily Return**	**Return-squared**
T	S	$S_t \div S_{t-1}$	$\mu_t = \ln(S_t \div S_{t-1})$	μ_t^2
0	50.00			
1	50.50	1.0100	0.0100	0.0001
2	51.00	1.0099	0.0099	0.0001
3	50.25	0.9853	-0.0148	0.0002
4	49.50	0.9851	-0.0150	0.0002
5	49.25	0.9949	-0.0051	0.0000
6	49.00	0.9949	-0.0051	0.0000
7	50.50	1.0306	0.0302	0.0009
8	51.00	1.0099	0.0099	0.0001
9	51.25	1.0049	0.0049	0.0000
10	52.00	1.0146	0.0145	0.0002
11	52.50	1.0096	0.0096	0.0001
12	53.00	1.0095	0.0095	0.0001
13	52.75	0.9953	-0.0047	0.0000
14	52.50	0.9953	-0.0048	0.0000
15	52.00	0.9905	-0.0096	0.0001
Total			**0.0392**	**0.0023**

n = 15 n - 1 = 14

n x (n-1) = 210

Estimate 's' of standard deviation of daily return, μ_t is given by

$$\sqrt{\left\{1 \div (n-1) \times \sum \mu t^2\right\} - \left\{1 \div n(n-1) \times (\sum \mu t)^2\right\}}$$

i.e. $\sqrt{\left\{1 \div (14) \times 0.0023\right\} - \left\{1 \div 210 \times (0.0392)2\right\}}$

i.e. 0.01239

Estimate of annual volatility, $\hat{\sigma}$, is 0.01239 X √252, taking 252 to be the number of trading days in the year. Thus, estimate for annual volatility is 0.1967 (i.e. 19.67%).

While working with weekly returns, s is to be multiplied by √52; in the case of monthly returns, s is to be multiplied by √12

Standard error of this estimate is $\hat{\sigma} \div \sqrt{2n}$

i.e. 0.1967 ÷ $\sqrt{2 \ x \ 15}$

i.e. 0.0359 (3.59% p.a.)

If the stock pays a dividend, then on the ex-dividend date, the dividend is to be added back while calculating the price factor.

6.2 ARCH(m) Model

The calculation in Table 6.1 gave equal importance to all the days. It can be argued that the more recent data is more important than the earlier data. Autoregressive Conditional Heteroskedasticity (ARCH) models can handle this. Broadly, the model can be defined as follows:

$$\sigma_n{}^2 = \sum_{i=1}^{m} \alpha \ i \ \mu^2 n\_i$$

Where, α_i is the weight given to the observation i days ago. The weights are given such that the weight for the ith observation is more than that for the i-1th observation; i-1th observation has more weightage than i-2th observation, and so on. The total of all the weightages should be equal to 1 i.e. = 1.

1 i.e. $\sum_{i=1}^{m} \alpha \ i = 1$

The model can be modified with a provision for a long term average variance (V_L) with a weightage of γ. The revised model then becomes

$$\sigma_n{}^2 = Y^{V}{}_L + \sum_{i=1}^{m} \alpha \ i \ \mu^2 n\_i$$

with $Y + \sum_{i=1}^{m} \alpha \ i = 1$

γV_L can be written as ω

Thus, $\sigma_n{}^2 = \omega + \sum_{i=1}^{m} \alpha \ i \ \mu^2 n\_i$

This is the ARCH(m) model conceptualised by Engle.

6.3 Exponentially Weighted Moving Average (EWMA)

The ARCH(m) model can be simplified by assuming that the weights α_i decrease exponentially by a constant factor, λ for every prior observation, where λ is a constant that takes a value between 0 and 1. With this, volatility can be easily calculated as per the following formula:

$\sigma_n^2 = \lambda\sigma_{n-1}^2 + (1-\lambda)\,\mu_{n-1}^2$

Thus, volatility can be easily estimated based on just 3 variables.

Suppose, constant factor, $\lambda = 0.94$, volatility estimate for yesterday, $\sigma_{n-1} = 0.02$ and change in value of the asset yesterday, $\mu_{n-1} = 0.05$.

$\sigma_n^2 = (0.94 \text{ X } 0.02^2) + (0.06 \text{ X } 0.05^2)$ i.e. 0.000526

Volatility estimate for today, σ_n is 2.29%

EWMA is widely used in margin calculations for risk management in the exchanges.

6.4 GARCH Model

Generalised Autoregressive Conditional Heteroskedasticity (GARCH) models represent a further refinement. The equation is written as follows:

$\sigma_n^2 = \gamma V_L + \alpha\,\mu_{n-1}^2 + \beta\sigma_{n-1}^2$

where, $\gamma + \alpha + \beta = 1$

GARCH models are described in terms of the number of observations used in calculating μ and σ.

GARCH (p,q) means that the most recent p observations of μ and the most recent q observations of σ.

GARCH (1,1) is commonly used. The EWMA model discussed above is a special case of GARCH (1,1) with $\gamma = 0$, $\alpha = 1 - \lambda$ and $\beta = \lambda$.

6.5 Implied Volatility

The volatility estimation discussed so far considered historical volatility based on price movement of a market variable, such as price of a stock. Volatility of the stock in turn affected the value of the stock option through a model like Black Scholes.

The Black Scholes model gives the theoretical value of the option, given historical volatility (and other parameters that the model is based on). The actual option premia in the market are likely to be different from the theoretical estimates.

Given the market price of an option, and the parameters other than volatility, it is possible to do the Black Scholes calculation backwards, to arrive at the volatility implicit in the price. This is the implied volatility.

Implied volatility of a contract is the same for the whole market. However, historical volatility used by different market participants varies, depending on the periodicity of data, period covered by the data and the model used for the estimation of volatility. Given the difference in historic volatility, the option value calculated using the same Black Scholes model varies between market participants.

Implications of historical volatility, implied volatility and the volatility index are discussed in Chapter 10.

Points to remember

- Volatility of a stock is a measure of the uncertainty of the annual returns provided by it. More the data points, better the estimate. A thumb rule is to have as many days' return data as the number of days to which the volatility is to be applied.
- Estimate 's' of standard deviation of daily return, μ_t is given by
  $\sqrt{\left\{1 \div (n-1) \times \sum \mu t^2\right\} - \{1 \div n(n-1) \times (\sum \mu t)^2\}}$
- Estimate of annual volatility, $\hat{\sigma}$, is s X √252, taking 252 to be the number of trading days in the year.
- While working with weekly returns, s is to be multiplied by √52; in the case of monthly returns, s is to be multiplied by √12
- Standard error of this estimate is $\hat{\sigma} \div \sqrt{2n}$
- If the stock pays a dividend, then on the ex-dividend date, the dividend is to be added back while calculating the price factor.
- GARCH models are used for more advanced measurements of volatility.
- Autoregressive Conditional Heteroskedasticity (ARCH) models give more importance to more recent data, in the estimation of volatility.
- ARCH models are defined by the equation $\sigma_n{}^2 = \sum_{i=1}^{m} \alpha\, i\ \mu^2 n\_i$

  Where, α_i is the weight given to the observation i days ago.
- The model can be modified with a provision for a long term average variance (V_L) with a weightage of γ. The revised model then becomes

  $\sigma_n{}^2 = Y^V{}_L + \sum_{i=1}^{m} \alpha\, i\ \mu^2 n\_i$
- The ARCH(m) model can be simplified by assuming that the weights α_i decrease exponentially by a constant factor, λ for every prior observation, where λ is a constant

that takes a value between 0 and 1. This gives the exponentially weighted moving average (EMWA) model, which is defined by the equation $\sigma_n^2 = \lambda\sigma_{n-1}^2 + (1-\lambda)\, \mu_{n-1}^2$. EWMA is widely used in margin calculations for risk management in the exchanges.

- Generalised Autoregressive Conditional Heteroskedasticity (GARCH) models represent a further refinement. The equation is defined as $\sigma_n^2 = \Upsilon V_L + a\, \mu_{n-1}^2 + \beta\sigma_{n-1}^2$
- GARCH models are described in terms of the number of observations used in calculating μ and σ. GARCH (p,q) means that the most recent p observations of μ and the most recent q observations of σ.
- GARCH (1,1) is commonly used. The EWMA model is a special case of GARCH (1,1) with $\gamma = 0$, $\alpha = 1 - \lambda$ and $\beta = \lambda$.
- The Black Scholes model gives the theoretical value of the option, given historical volatility (and other parameters that the model is based on). The actual option premia in the market are likely to be different from the theoretical estimates.
- Given the market price of an option, and the parameters other than volatility, it is possible to do the Black Scholes calculation backwards, to arrive at the volatility implicit in the price. This is the implied volatility.
- Historical volatility used by different market participants varies, depending on the periodicity of data, period covered by the data and the model used for the estimation of volatility. Given the difference in historic volatility, the option value calculated using the same Black Scholes model varies between market participants.

Self-Assessment Questions

❖ Annual volatility is calculated by multiplying the standard deviation by

➢ 252

➢ √252

➢ 252^2

➢ **Depends on frequency of data**

❖ ARCH Models are characterised by

➢ Equal importance to all data

➢ **More importance to more recent data**

➢ More importance to data relating to stable market conditions

➢ None of the above

- In a GARCH (p,q), p refers to
  - σ
  - μ
  - **Number of observations of μ**
  - Number of observations of σ
- EWMA stands for
  - Excess Weighted Moving Average
  - **Exponentially Weighted Moving Average**
  - Exponentially Weighted Market Average
  - Excess Weighted Markovitz Average
- Historic volatility depends on
  - Periodicity of data
  - Period covered by the data
  - Model used
  - **All the above**
- Which of the following is true?
  - **Option premia in market depend on historical volatility**
  - Theoretic valuation of option depends on implied volatility
  - Both the above
  - None of the above

Chapter 7: Basic Option& Stock Positions

The two option types, call and put were discussed earlier. With either option contract, one can buy (go long) or sell / write (go short). Accordingly, there are four basic option positions.

7.1 Pay-off Matrix for Basic Option Positions

Options are typically assessed through their pay-off matrix viz. how the profit / loss changes as the price changes. Let us consider an option with exercise price Rs. 80, available in the market for a premium of Rs. 5. B is considering buying the option from S. The pay-off for the four option positions are discussed below.

7.1.1 Long Call

Suppose the option was a call, and the prevailing market price for the underlying share is Rs. 84.

The intrinsic value of the option is Rs. 84 – Rs. 80 i.e. Rs. 4. Time value of the option is Rs. 5 – Rs. 4 i.e. Rs. 1.

So long as the market price is below Rs. 80, the option has no intrinsic value. B's loss is capped at the premium of Rs. 5.

As the price goes above Rs. 80, the option begins acquiring an intrinsic value. If the market price is Rs. 82, B will exercise the option. The gain in intrinsic value of Rs. 2 is still lesser than the Rs. 5 paid as option premium.

Only when the market price crosses Rs. 85, B starts earning a profit. Higher the market price, greater the profit. The pay-off matrix thus acquires the shape given in Figure 7.1.

7.1.2 Short Call

The position of S is the reverse. So long as B does not exercise the option (i.e. market price is below Rs. 80), the option premium is his profit. S's gain is capped at the premium of Rs. 5.

If the price goes above Rs. 80, B will exercise his option. If the market price is Rs. 82, S will lose (Rs. 82 – Rs. 80) i.e. Rs. 2 on the stock. The loss on the stock is still lesser than the Rs. 5 received as option premium. So S earns a profit of (Rs. 5 – Rs. 2) i.e. Rs. 3.

Only when the market price crosses Rs. 85, S starts losing money on the entire position. Higher the market price, greater the loss. The pay-off matrix thus acquires the shape given in Figure 7.2.

Figure 7.1

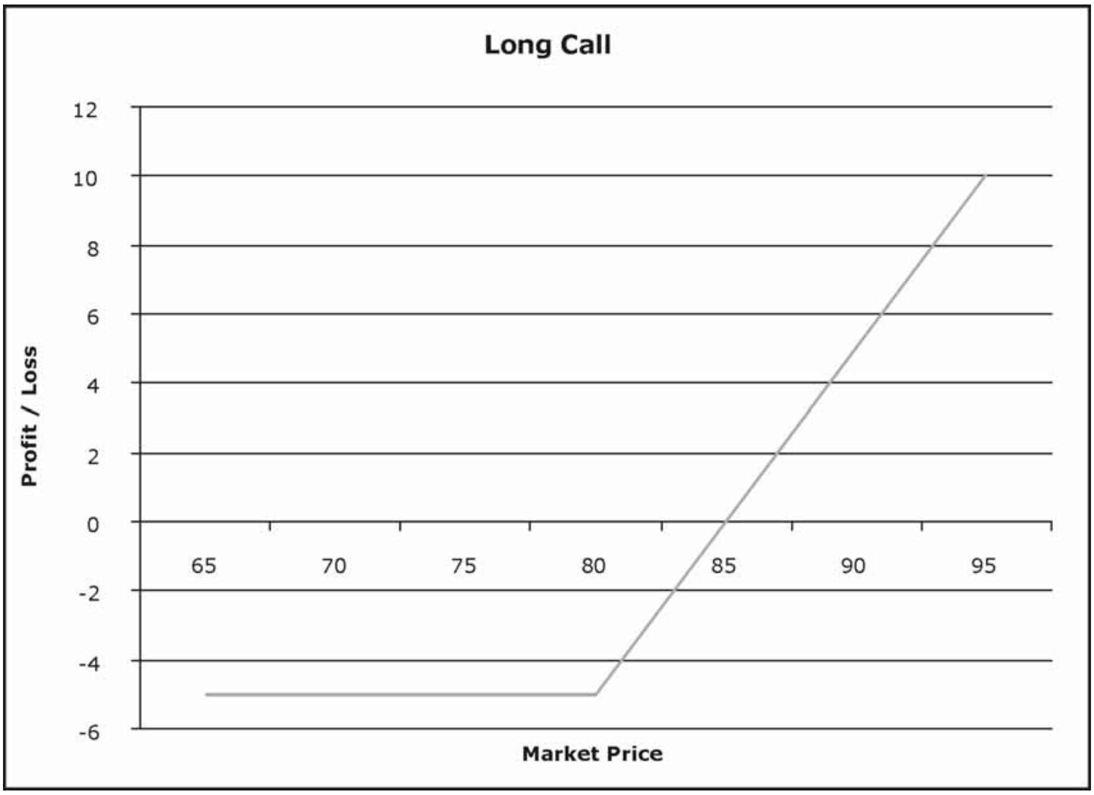
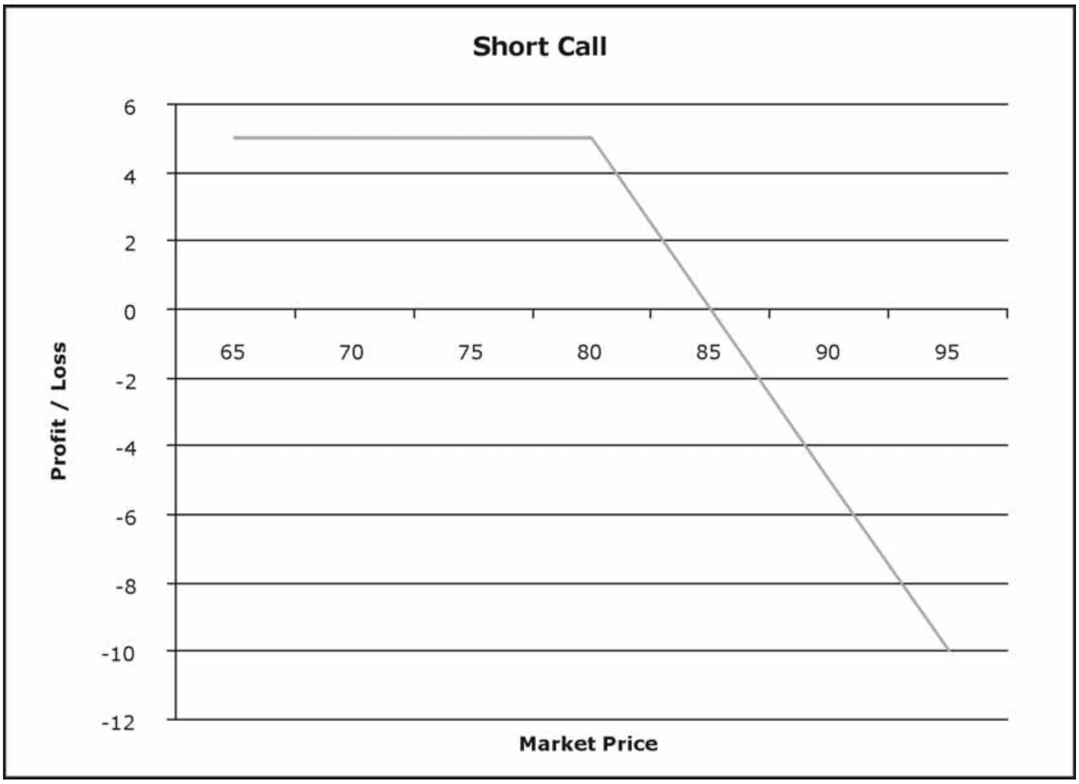


Figure 7.2



7.1.3 Long Put

Suppose the option was a put, and the prevailing market price for the underlying share is Rs. 76.

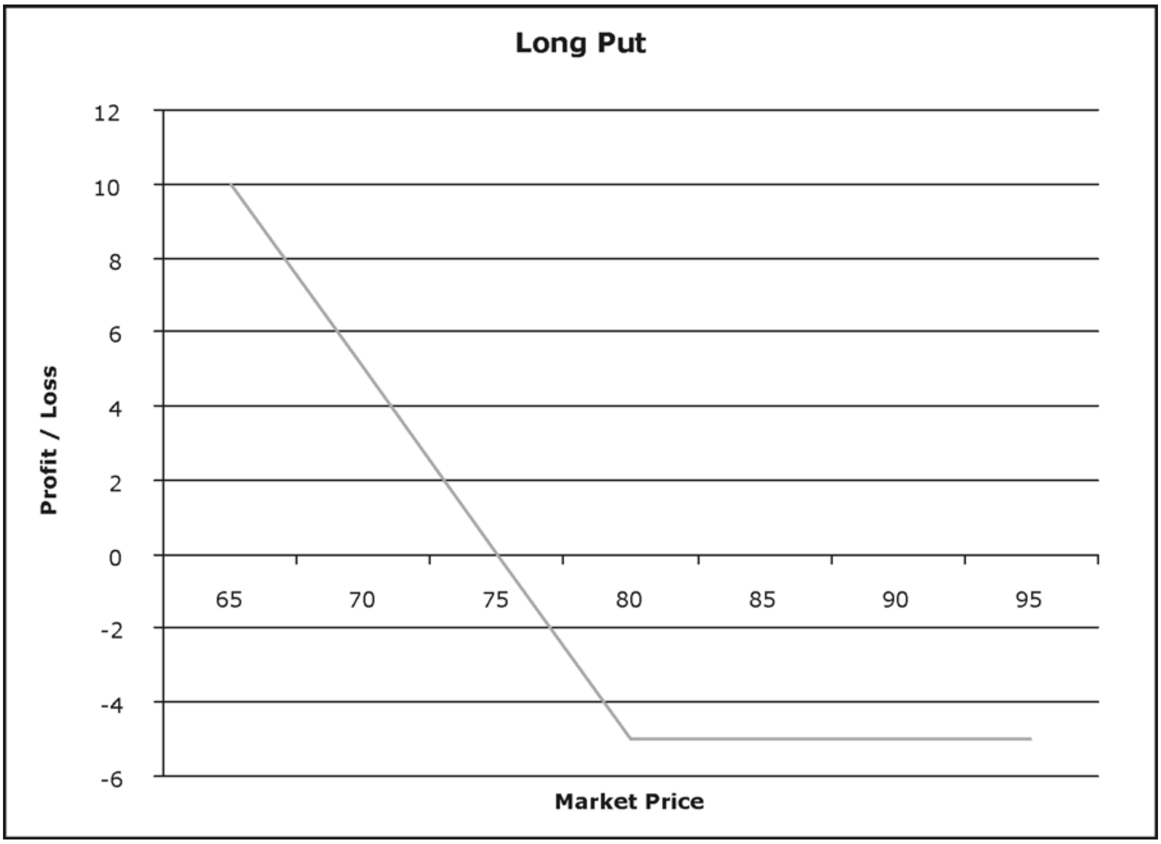
The intrinsic value of the option is Rs. 80 – Rs. 76 i.e. Rs. 4. Time value of the option is Rs. 5 – Rs. 4 i.e. Rs. 1.

So long as the market price is above Rs. 80, the option has no intrinsic value. B's loss is capped at the premium of Rs. 5.

As the price goes below Rs. 80, the option begins acquiring an intrinsic value. If the market price is Rs. 78, B will exercise the option. The gain in intrinsic value of Rs. 2 is still lesser than the Rs. 5 paid as option premium.

Only when the market price goes below Rs. 75, B starts earning a profit. Lower the market price, greater the profit. The pay-off matrix thus acquires the shape given in Figure 7.3.

Figure 7.3



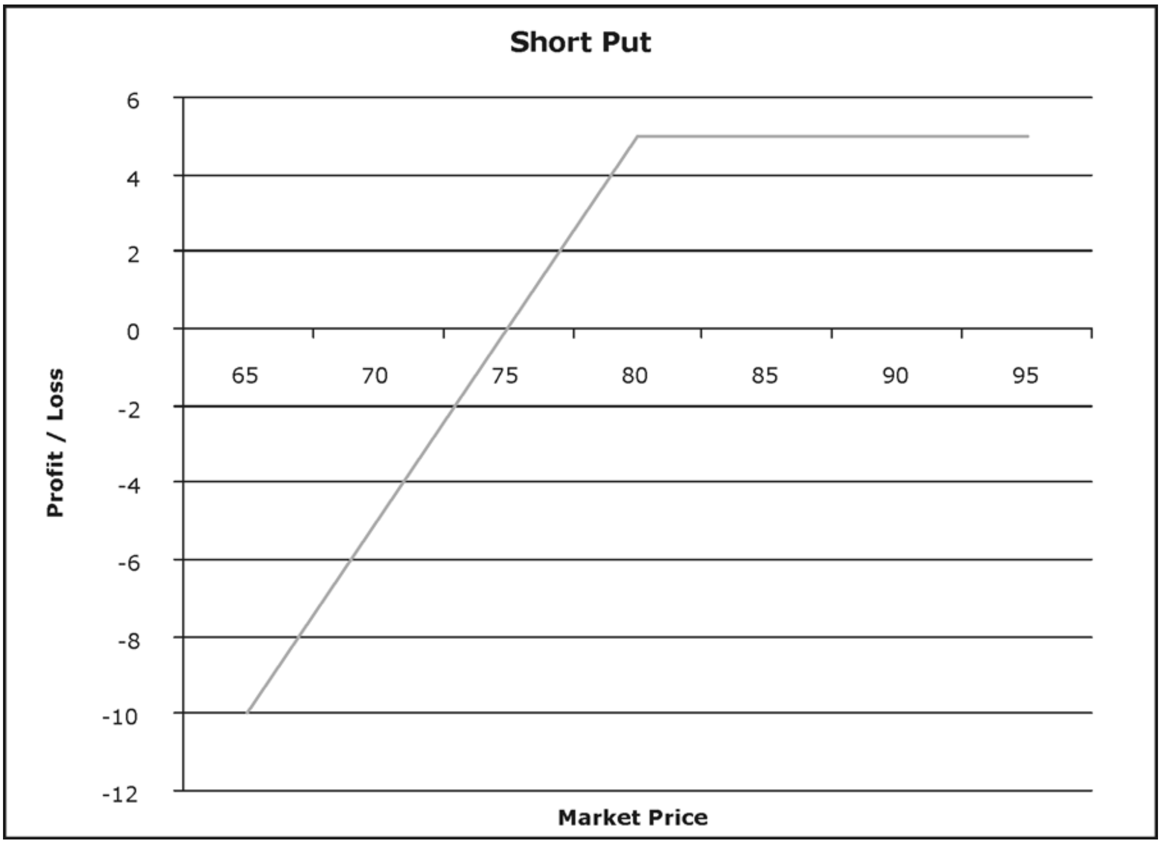
7.1.4 Short Put

The position of S is the reverse. So long as B does not exercise the option (i.e. market price is above Rs. 80), the option premium is his profit. S's gain is capped at the premium of Rs. 5.

If the price goes below Rs. 80, B will exercise his option. If the market price is Rs. 78, S will lose (Rs. 80 – Rs. 78) i.e. Rs. 2 on the stock. The loss on the stock is still lesser than the Rs. 5 received as option premium. So S earns a profit of (Rs. 5 – Rs. 2) i.e. Rs. 3.

Only when the market price goes below Rs. 75, S starts losing money on the entire position. Lower the market price, greater the loss. The pay-off matrix thus acquires the shape given in Figure 7.4.

Figure 7.4



The worst loss in a short put position is that on exercise, the asset is worthless. Thus, the worst loss in the above example is Rs. 80 – Rs. 5 i.e. Rs. 75.

7.2 Pay-off Matrix for Position in the Share

Investors can buy a share (i.e. go long) or sell a share that they do not have (i.e. go short).

7.2.1 Long Stock

Continuing with the example, suppose the share is trading at Rs. 80. A person who has gone long on the stock at this price will make profits if the share price goes up; he will lose if the share price goes below Rs. 80. The pay-off matrix is shown in Figure 7.5.

7.2.2 Short Stock

A person who has gone short on the stock at Rs. 80, will make profits if the share price goes down; he will book losses if the share price goes above Rs. 80. The pay-off matrix is shown in Figure 7.6.

Figure 7.5

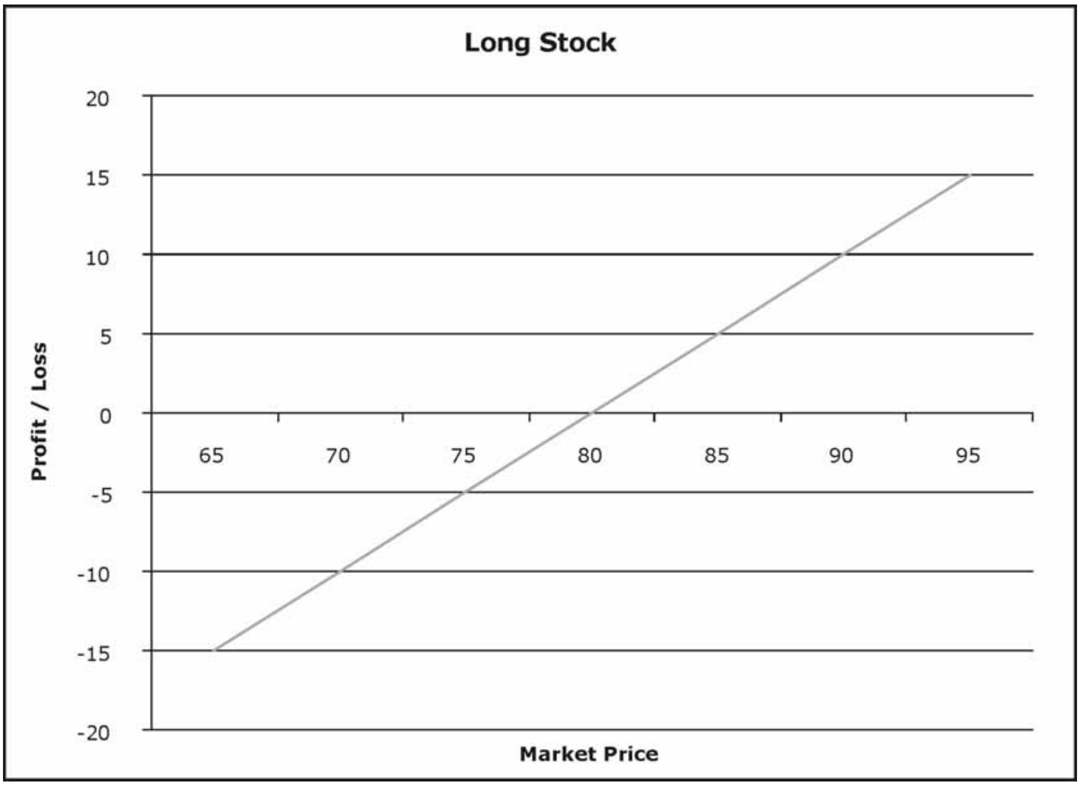
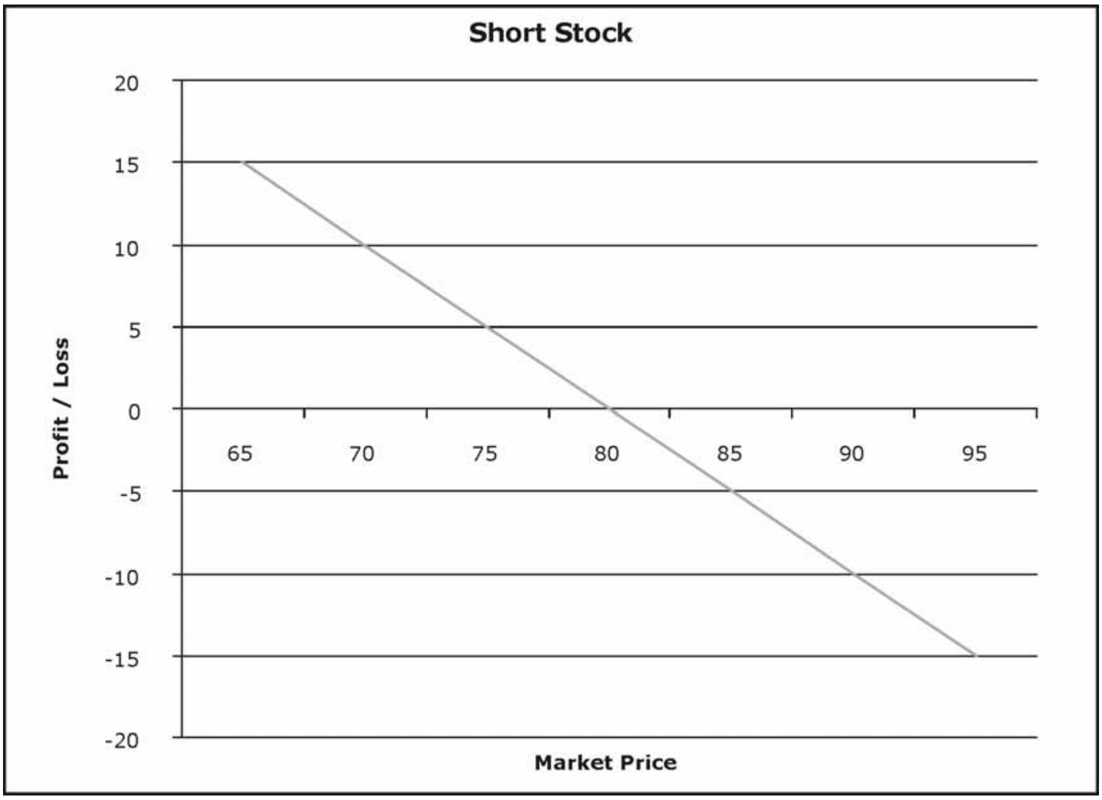


Figure 7.6



7.3 Assumptions

The above charts were kept simple by minimising the variables. It will be useful to understand the implicit assumptions:

- Assumption: There are no transaction costs

  In reality, brokers will charge a brokerage. Also securities transaction tax is applicable.

- Assumption: There are no margin payments.

  Normally, the exchange would impose margins until the trades are settled.

- Time value of money has been ignored.

  In the real world, when premium of Rs. 5 is paid by the buyer (or received by the seller) of the option, there is an interest cost / income for the buyer / seller on account of the premium.

- The profit / loss above does not consider income tax nuances such as differential taxes on long term and short term capital gains / losses, provisions regarding set off of losses against gains etc.

- As discussed in Chapter 4, exercising a call option entails a cash outflow, which the buyer of the option may not be interested in incurring (unless there is scope to receive an attractive dividend on the shares acquired through the exercise). In most cases, therefore, he will prefer to reverse his position by selling the option, instead of exercising the right to buy the share (and then having to sell that share, with more brokerage to incur on the sale).

  While reversing the position, the gain / loss may not be the same as the movement in the share price. The movement in share price will reflect in the intrinsic value of the option. Option prices in the market change on account of both elements – intrinsic value and time value.

7.4 A Few Option Contract Intricacies

- The pay-off line for the stock is a straight line in the case of both, long and short positions in the stock. The pay-off is said to be symmetric. As was seen earlier, the pay-off line for the options is a bent line, in the case of both, long and short positions in either option type. The pay-off is said to be asymmetric.

  This difference in pay-off profile leads to various option strategies that either use options alone, or combine options with stocks. These strategies are discussed in the following Chapters.

- All of options on the same underlying (e.g. Nifty) are said to belong to the same class.

  When options of the same class have the same expiry and strike (e.g. May 31, 2012 and 4,900), they are said to be of the same series.

- When the holder of an option chooses to exercise, the clearing house assigns that exercise to one of the option sellers who has an open position in contracts of the same series. This is called assignment.

  - If it is a call option, the concerned option seller needs to deliver stock to the holder of that exercised option;

  - If it is a put option, the concerned option seller needs to buy stock from the holder of that exercised option.

Accordingly, the option seller will receive the exercise price (if it is a call option) or pay the exercise price (if it is a put option).

While the explanations are given in the context of stocks, the pay-off profiles are equally applicable for other asset types too.

- So long as an option has got time value, it is less likely to be exercised. Closer to maturity, it loses its time value and is more likely to be exercised.

- Option sellers who want to avoid exercise will roll over their position before the likely exercise. For example, if someone has sold a Nifty 4900 call for May 31 maturity, he will buy a Nifty 4900 call for May 31 maturity (to reverse the earlier position, and buy a fresh Nifty call for June 28 maturity. This is called roll over of position.

Points to remember

- In a long call, the loss is limited to the premium paid. Beyond the exercise price, as the market price goes up, the long call position starts making money. It breaks even, when the market price touches a level equal to the exercise price plus the premium. The profit potential in a long call position is unlimited.

- In a short call, the loss is unlimited, but profit is limited to the premium earned. It breaks even, when the market price touches a level equal to the exercise price plus the premium. Above that price, the call writer loses money.

- The loss in long put position is limited to the premium paid. Below the exercise price, lower the market price, higher the profit from a put position. The position breaks even, when the market price touches a level equal to the exercise price minus the premium.

- The profit in a short put position is limited. As the market price goes below the exercise price, the position starts losing money. The loss is however limited to the exercise price minus premium received.
- In a long stock position, the loss is limited to the price paid for the stock. The profit potential is unlimited
- A short stock position has unlimited loss potential. However, maximum profit is limited to the price at which the stock has been sold.
- The pay off line for a stock is a straight line i.e. it is symmetric. The line for options is asymmetric.
- All of options on the same underlying (e.g. Nifty) are said to belong to the same class.
- When options of the same class have the same expiry and strike (e.g. May 31, 2012 and 4,900), they are said to be of the same series.
- When the holder of an option chooses to exercise, the clearing house assigns that exercise to one of the option sellers who has an open position in contracts of the same series. This is called assignment.
- So long as an option has got time value, it is less likely to be exercised. Closer to maturity, it loses its time value and is more likely to be exercised.
- Option sellers who want to avoid exercise will roll over their position before the likely exercise.

Self-Assessment Questions

❖ In which of the following is the loss unlimited?

  ➢ Long call

  ➢ Long put

  ➢ **Short call**

  ➢ Short put and Short call

❖ In a long call, maximum loss is

  ➢ **Premium paid**

  ➢ Exercise price plus premium

  ➢ Exercise price minus premium

  ➢ Market price minus exercise price

- In a short call, profit is
    - Unlimited
    - **Limited to premium**
    - Premium plus Market price minus exercise price
    - Premium minus exercise price
- The pay-off in which of the following is asymmetric?
    - Stock
    - **Options**
    - Both the above
    - None of the above
- A long put position breaks even at
    - The premium
    - The exercise price
    - **Exercise price minus premium**
    - Exercise price plus premium
- All options on the same underlying
    - Are traded in the same exchange
    - **Belong to the same class**
    - Belong to the same series
    - Are settled by the same settlement house.

Chapter 8: Option Trading Strategies

8.1 The Strategies

NCFM's Workbook titled "Options Trading Strategies" detailed various strategies for trading options. In order to internalise understanding of their structure and pay off, it is useful to group the strategies as follows:

8.1.1 Single Option, Single Stock

This group of options is understood better in the context of the put-call parity formula discussed in Chapter 1.

8.1.1.1. Protective Put

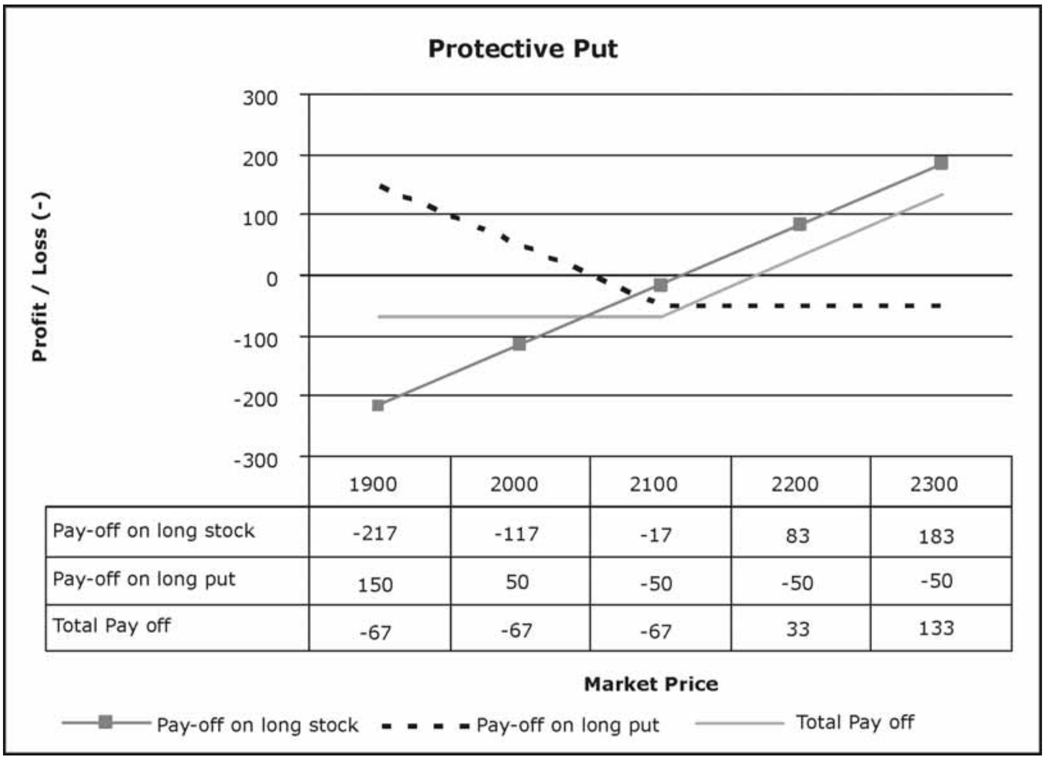
As per put-call parity formula, $C + D + Ke^{-rT} = P + S_0$

This means that a call on a stock, with some money in hand ($D + Ke^{-rT}$) is equivalent to holding the stock and being long on a put on that stock. Therefore, the pay-off from holding a stock and a put on it (the structure of a Protective Put) takes the shape of a long call as seen in Figure 8.1. Hence the alternate name for this strategy - "synthetic long call".

This strategy is suitable when the investor is bullish about the stock, but has some concern about possible declines.

Suppose SBI share is trading on at Rs. 2,117. Near month Put with strike at Rs. 2,100 is available at Rs. 50.

Figure 8.1



	1900	2000	2100	2200	2300
Pay-off on long stock	-217	-117	-17	83	183
Pay-off on long put	150	50	-50	-50	-50
Total Pay off	-67	-67	-67	33	133

Investor goes long on both stock and put, paying Rs. 2,117 + Rs. 50 = Rs. 2,167. This is the breakeven point i.e. when market price reaches this point, investor breaks even.

Above the breakeven point, the investor has an unlimited profit potential.

Worst case for the investor is Rs. 2,100 – Rs. 2,117 - Rs. 50 i.e.-Rs. 67.

8.1.1.2. Covered Put

Instead of going long on the stock and the put, the investor can go short on both. The position can be presented by re-working the put-call formula as follows:

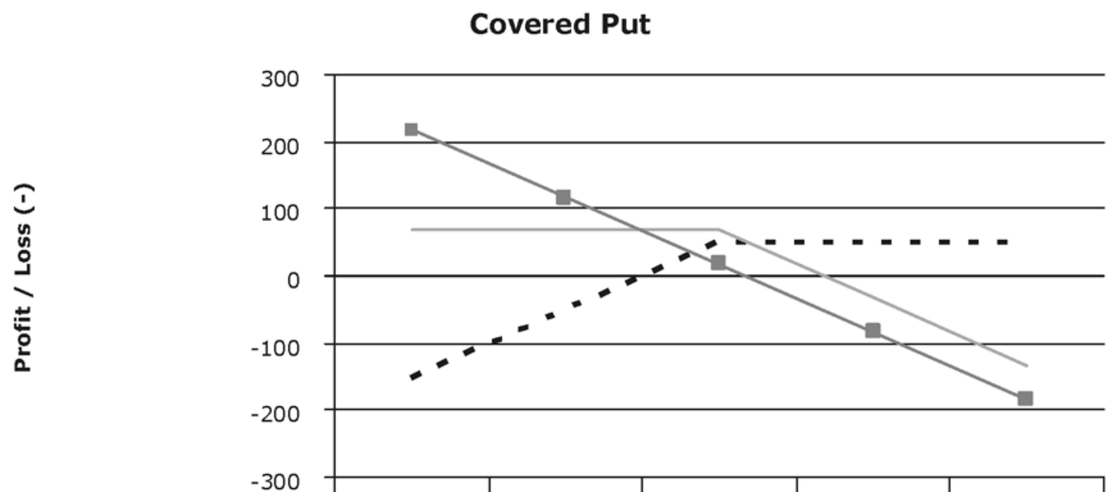
$-C - (D + Ke^{-rT}) = - P - S_0$

Therefore, the pay-off will be similar to a short call, as seen in Figure 8.2.

This strategy is suitable when the view is moderately bearish or sideways.

Suppose SBI share is trading on at Rs. 2,117. Near month Put with strike at Rs. 2,100 is available at Rs. 50.

Figure 8.2



	1900	2000	2100	2200	2300
Pay-off on short stock	217	117	17	-83	-183
Pay-off on short put	-150	-50	50	50	50
Total Pay off	67	67	67	-33	-133

Investor goes short on both stock and put, receiving Rs. 2,117 + Rs. 50 = Rs. 2,167. This is the breakeven point i.e. when market price reaches this point, investor breaks even.

Above the breakeven point, the investor can book unlimited losses.

Best case for the investor is Rs. 2,117 – Rs. 2,100 + Rs. 50 i.e.Rs. 67.

8.1.1.3. Covered Call

The investor can write a call and cover himself by buying the stock. This structure is also called "Buy-Write". The position can be presented by re-working the put-call formula as follows:

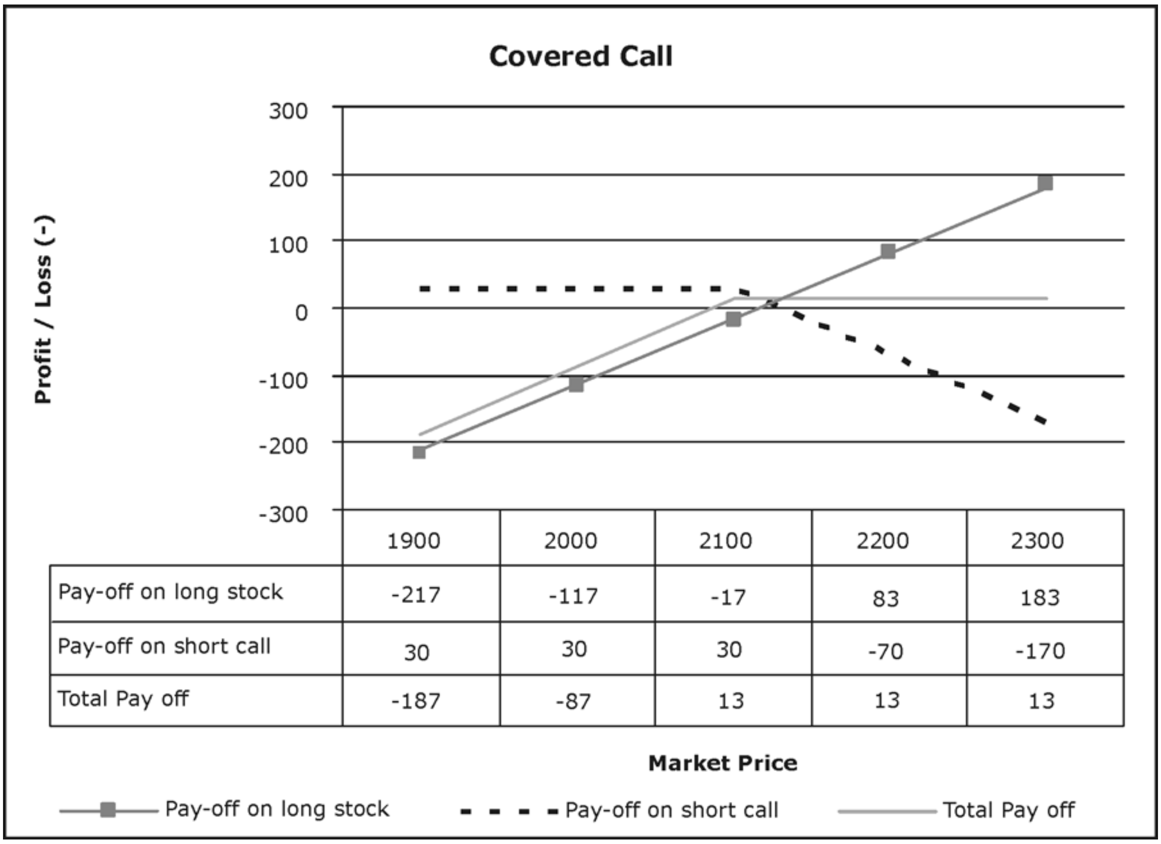
$S_0 - C = - P + (D + Ke^{-rT})$

Therefore, the pay-off will be similar to a short put, as seen in Figure 8.3.

This strategy is suitable when the view is moderately bullish or sideways.

Suppose SBI share is trading on at Rs. 2,117. Near month call with strike at Rs. 2,100 is available at Rs. 30.

Figure 8.3



	1900	2000	2100	2200	2300
Pay-off on long stock	-217	-117	-17	83	183
Pay-off on short call	30	30	30	-70	-170
Total Pay off	-187	-87	13	13	13

Investor goes long on the stock and short on the call, paying Rs. 2,117 - Rs. 30 = Rs. 2,087. This is the breakeven point i.e. when market price reaches this point, investor breaks even.

Below the breakeven point, the investor can book significant losses. The worst case is that the stock is worth nothing and the call is not exercised. In that case, the entire amount invested initially viz. Rs. 2,087 would be lost.

Best case for the investor is Rs. 2,100 – Rs. 2,117 + Rs. 30 i.e.Rs. 13.

8.1.1.4. Protective Call

The investor can do the reverse of a covered call viz. buy a call and short-sell the stock. The position can be presented by re-working the put-call formula as follows:

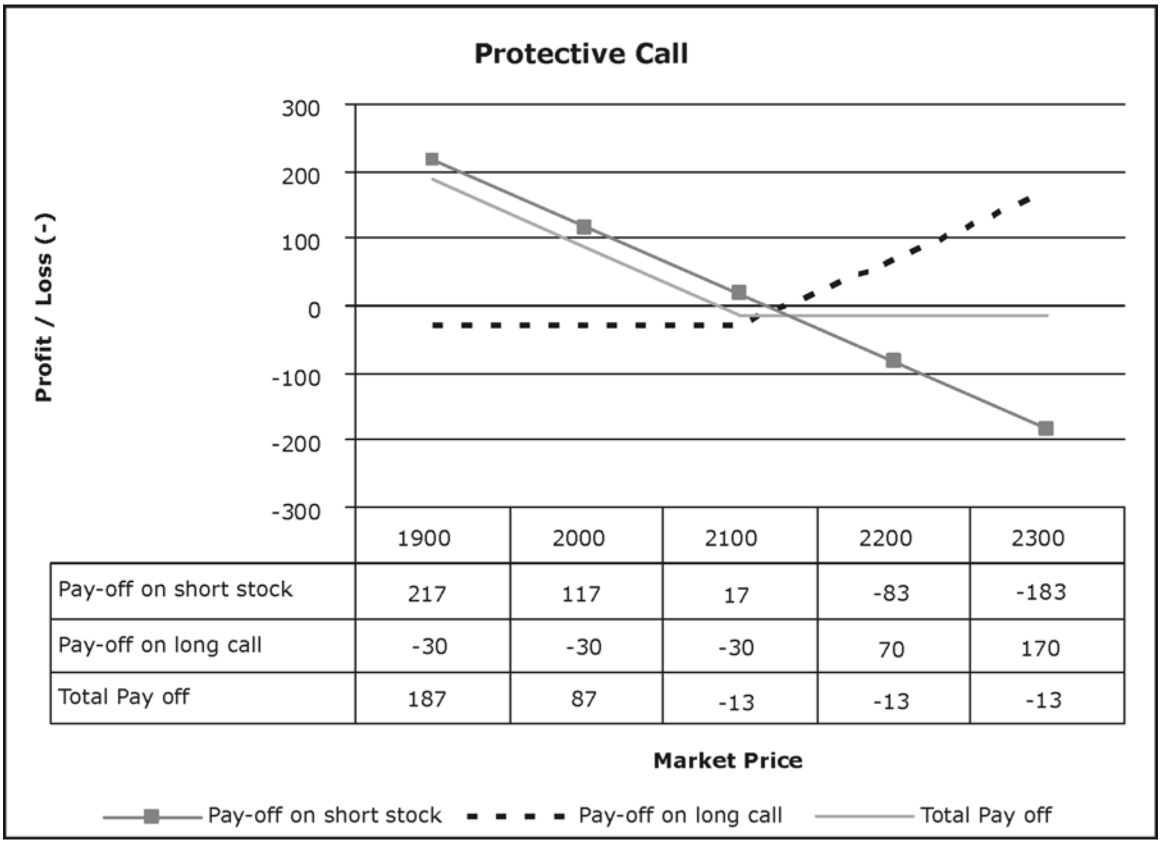
$C - S_0 = P - (D + Ke^{-rT})$

Therefore, the pay-off will be similar to a long put, as seen in Figure 8.4. The strategy is therefore also called as synthetic long put.

This strategy is suitable when the view is bearish, with some concern about a potential increase.

Suppose SBI share is trading on at Rs. 2,117. Near month call with strike at Rs. 2,100 is available at Rs. 30.

Figure 8.4



	1900	2000	2100	2200	2300
Pay-off on short stock	217	117	17	-83	-183
Pay-off on long call	-30	-30	-30	70	170
Total Pay off	187	87	-13	-13	-13

Investor goes short on the stock and long on the call, receiving Rs. 2,117 - Rs. 30 = Rs. 2,087. This is the breakeven point i.e. when market price reaches this point, investor breaks even.

Below the breakeven point, the investor can earn significant profits. The best case is that the short-sold stock is worth nothing. The profit in that case would be the Rs. 2087 already received.

Worst case for the investor is Rs. 2,117 – Rs. 2,100-Rs. 30 i.e. -Rs. 13.

8.1.2 Multiple Options of Same Type

Since the options are of the same type, the investor seeks to participate in spread differences. Therefore, such option trading strategies are also called spreads. Some of these spread structures are as follows:

(Only a brief description is given for structures that are adequately described in NCFM's Workbook titled "Options Trading Strategies". Please check that Workbook for the detailed graphs and pay-off structures.)

8.1.2.1. Bull Spread

In this type of spread, the investor earns profits if the market is up. Since the profit from this spread is capped, the strategy is appropriate only when the market is moderately bullish.

The bull spread can be built using either Calls or Puts. Accordingly, it can be a Bull Call Spread or a Bull Put Spread.

In a Bull Call Spread, a call option is bought and another call option sold on the same stock with the same expiry. The call option sold has a higher strike price (say, K_2) as compared to the call option bought (with exercise price of K_1).

Since the call sold has a higher strike price, it would have yielded a lower premium than the premium paid on call purchased. Therefore, initially there will be a net outflow of premium.

- If the market price of the stock is below K_1, then neither call option will be exercised. Loss for the investor would be the initial net outflow of premium.
- If the market price of the stock is between $K_1$and K_2, then investor will exercise the call purchased, thus gaining the difference between the market price and K_1. The call sold will lapse.
- If the market price of the stock is above K_2, then both calls will be exercised. On the call purchased, investor will gain the difference between the market price and K_1. However, on the call sold, investor will lose the difference between market price and K_2. Net profit on the exercise of both options would be $K_2 – K_1$.

Bull Call Spreads that are created with options being out of the money are considered to be most aggressive. Benefit is that the net outflow of premium is negligible. Problem is that the market has to move significantly to yield the maximum gain of $K_2 – K_1$.

In a Bull Put Spread, a put option is bought and another put option sold on the same stock with the same maturity. The put option sold has a higher strike price. Therefore, premium received on sale of put will be more than the premium paid on putpurchased. Initially, investor has a net inflow of funds.

- If the market price of the stock is above K_2, then neither put option will be exercised. Gain for the investor would be the initial net inflow of premium.
- If the market price of the stock is between $K_1$and K_2, then the put sold will get exercised. Loss for the investor would be the difference between $K_2$and the market price. Investor will let the long put option lapse.
- If the market price of the stock is below K_1, then both puts will be exercised. On the put purchased, investor will gain the difference between the market price and K_1. However, on the put sold, investor will lose the difference between the market price and K_2. Net loss on the exercise of both options would be $K_2 - K_1$.

8.1.2.2. Bear Spread

In this type of spread, the investor earns profits if the market is down. However, since the profits are capped, this strategy is sensible only when the market is moderately bearish.

As in the case of bull spread, the bear spread too, can be built using Calls or Puts. Accordingly, it can be a Bear Call Spread or a Bear Put Spread.

In a Bear Call Spread, a call option is bought and another call option sold on the same stock with the same expiry. The call option bought has a higher strike price (say, K_2) as compared to the call option sold (with exercise price of K_1).

Since the call sold has a lower strike price, it would have yielded higher premium than the premium paid on call purchased. Therefore, initially there will be a net inflow of premium.

- If the market price of the stock is below K_1, then neither call option will be exercised. Gain for the investor would be the initial net inflow of premium.
- If the market price of the stock is between $K_1$and K_2, then the call option sold will get exercised. The investor will lose the difference between the market price and K_1. Investor will let the long call lapse.
- If the market price of the stock is above K_2, then both calls will be exercised. On the call purchased, investor will gain the difference between the market price and K_2. However, on the call sold, investor will lose the difference between market price and K_1. Net loss on the exercise of both options would be $K_2 - K_1$.

In a Bear Put Spread, a put option is bought and another put option sold on the same stock with the same maturity. The put option sold has a lower strike price. Therefore, premium received will be lesser than the premium paid on put sold. Initially, investor has a net outflow of funds.

- If the market price of the stock is above K_2, then neither put option will be exercised. Loss for the investor would be the initial net outflow of premium.

- If the market price of the stock is between $K_1$and K_2, then the put sold will lapse. Investor will exercise the long put. Gain for the investor would be the difference between $K_2$and the market price.
- If the market price of the stock is below K_1, then both puts will be exercised. On the put purchased, investor will gain the difference between $K_2$and the market price. However, on the put sold, investor will lose the difference between $K_1$and the market price. Net gain for the investor on the exercise of both options would be $K_2 - K_1$.

Bear Put Spreads that are created with options being out of the money are considered to be most aggressive. Benefit is that the net outflow of premium is negligible. Problem is that the market has to move significantly to yield the maximum gain of $K_2 - K_1$.

8.1.2.3. Butterfly Spread

This entails options with exercise at three different price levels, say, K_1, K_2 and K_3, with $K_1 < K_2 < K_3$and $K_2 - K_1 = K_3 - K_2$. Typically, K_2 is near the current stock price. Butterfly spreads can be created using call or put options.

One structure is to buy one call at K_1, another call at K_3 and sell two calls at K_2. All the options are on the same underlying for the same expiry.

- If the market price is below K_1, then all the calls will lapse.
- If the market price is between K_1 and K_2, then the investor will exercise the lowest strike call and earn the difference between the market price and K_1. Other calls will lapse.
- If the market price is between K_2 and K_3, then the investor will exercise the lowest strike call to earn the difference between market price and K_1. But the two calls sold will be exercised. The investor will lose twice the difference between the market price and K_2. The total pay off from all the three options exercised can be calculated to be the difference between K_3 and the market price.
- If the market price is above K_3, then all the calls will be exercised. On the lowest strike call, investor will earn the difference between the market price and K_1. On the highest strike price, the investor will earn the difference between the market price and K_3. This will be compensated by the loss on exercise of the calls written, equal to twice the difference between the market price and K_2. The net effect from the exercise of all the options would be zero.
- The maximum gain for the investor is when the market price is at K_2.

The above structure is a long call butterfly spread. A similar pay-off is possible through a long put butterfly spread, which would entail buying a put at K_1, another put at K_3 and selling two puts at K_2.

The long butterfly strategy (through calls or puts) makes profits if the market is range bound. For volatile markets, the investor can reverse the above positions to do a short call butterfly or short put butterfly.

8.1.2.4. Calendar Spread

Here, different options of the same type but different maturities are used. The underlying and strike price are held constant.

In a regular calendar spread, a shorter maturity call (or put) option is sold and longer maturity call (or put) option is purchased at the same strike price. Premium received will be less than premium paid. Therefore, initially there is a net outflow for the investor.

The payoff from a regular calendar spread is similar to a long butterfly strategy – maximum when the market is range bound.

A calendar spread is considered neutral, if the strike price is at the current market price. If the strike price is higher than the current market, it is considered to be a bullish calendar spread. Strike price lower than the current market would make it a bearish calendar spread.

In a reverse calendar spread, the option (put or call) bought is of a shorter maturity than the option sold. Premium received will be more than the premium paid. Therefore, investor initially receives net premium.

Reverse calendar spread earns some profits if the market moves significantly in either direction. If the market remains range bound, significant losses are possible.

8.1.2.5. Diagonal Spread

This strategy gets more complex because only the underlying is the same. Both maturity and strike price of the options used are different.

8.1.3 Multiple Options of Different Types

8.1.3.1. Straddle

In a long straddle, the investor buys a call and a put with the same strike price. Since two option contracts are purchased, the initial premium outflow is high.

If the stock price moves significantly in either direction, then payoff equivalent to the difference between the market price and strike price is earned. Therefore, a long straddle is suitable for volatile markets.

In a short straddle, the investor sells a call and a put with the same strike price. Since two option contracts are sold, the initial premium inflow is high.

A short straddle is a risky strategy, where the investor loses if the market moves in either direction. Only if the market closes at the strike price, will both options lapse.

8.1.3.2. Strangle

A strangle is slightly different from the straddle. Here, the two options bought (if it is a long strangle) or sold (if it is a short strangle) have different exercise prices.

In a long strangle, the investor expects a significant change in market, but is not clear about the direction of the change.

A short strangle – risky like a short straddle – is suitable when the investor expects that the market will be at or near the strike price.

8.1.3.3. Collar

This is a covered call plus downside protection. In a covered call, since the investor holds the stock, a decline in market leads to a loss. To protect against such loss, the investor buys a put.

This is a conservative strategy, where both gains and losses are capped through the call and put respectively. The strategy is suitable if the market view is moderately bullish.

8.1.3.4. Range Forward - Long

A range forward is a combination of a call and a put at different strike prices but the same maturity.

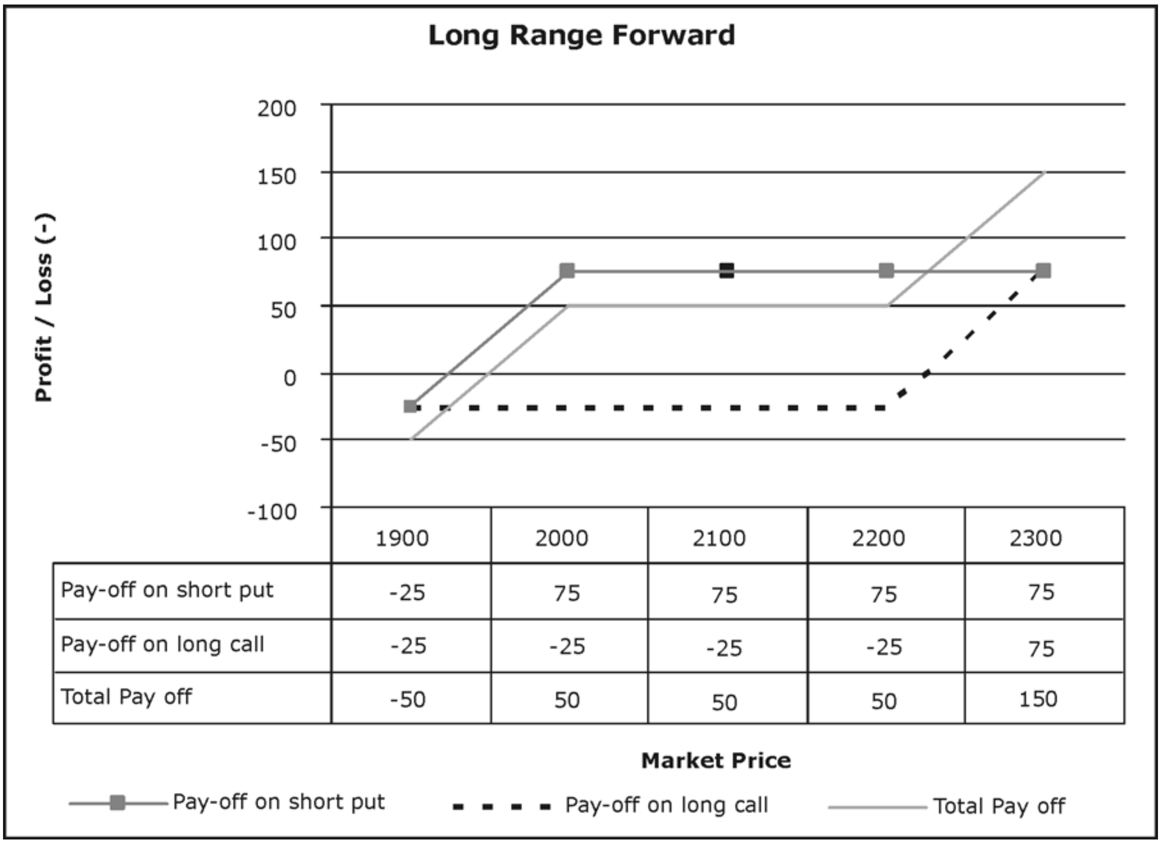
A long range forward is a combination of:

- Short position in put with strike price K_1.
- Long position in call with strike price K_2, where $K_1<K_2$

Suppose SBI is trading at Rs. 2,025. Rs. 2,000 put for 1-month is available at Rs. 75; Rs. 2,200 call for the same maturity is available at Rs. 25.

On account of the long range forward transaction, the investor will receive net premium of (Rs. 75 – Rs. 25) i.e. Rs. 50. The pay offs are shown in Figure 8.5.

Figure 8.5



	1900	2000	2100	2200	2300
Pay-off on short put	-25	75	75	75	75
Pay-off on long call	-25	-25	-25	-25	75
Total Pay off	-50	50	50	50	150

If the market price goes below Rs. 2,000, the put will get exercised. The investor will lose to the extent of (Market Price – Rs. 2,000). At a break-even price of Rs. 1,950, the loss of Rs. 50 on the short put option exercised is equal to the net premium earned when the long range forward position was initiated.

If the market price goes above Rs. 2,200, the investor will exercise the call option and gain to the extent of (Market Price – Rs. 2,200).

If the market price is between Rs. 2,000 and Rs. 2,200, then neither option will be exercised. The net premium of Rs. 50 earned earlier, becomes the total profit from the position.

A long range forward position is initiated when the market view is significantly bullish.

8.1.3.5. Range Forward - Short

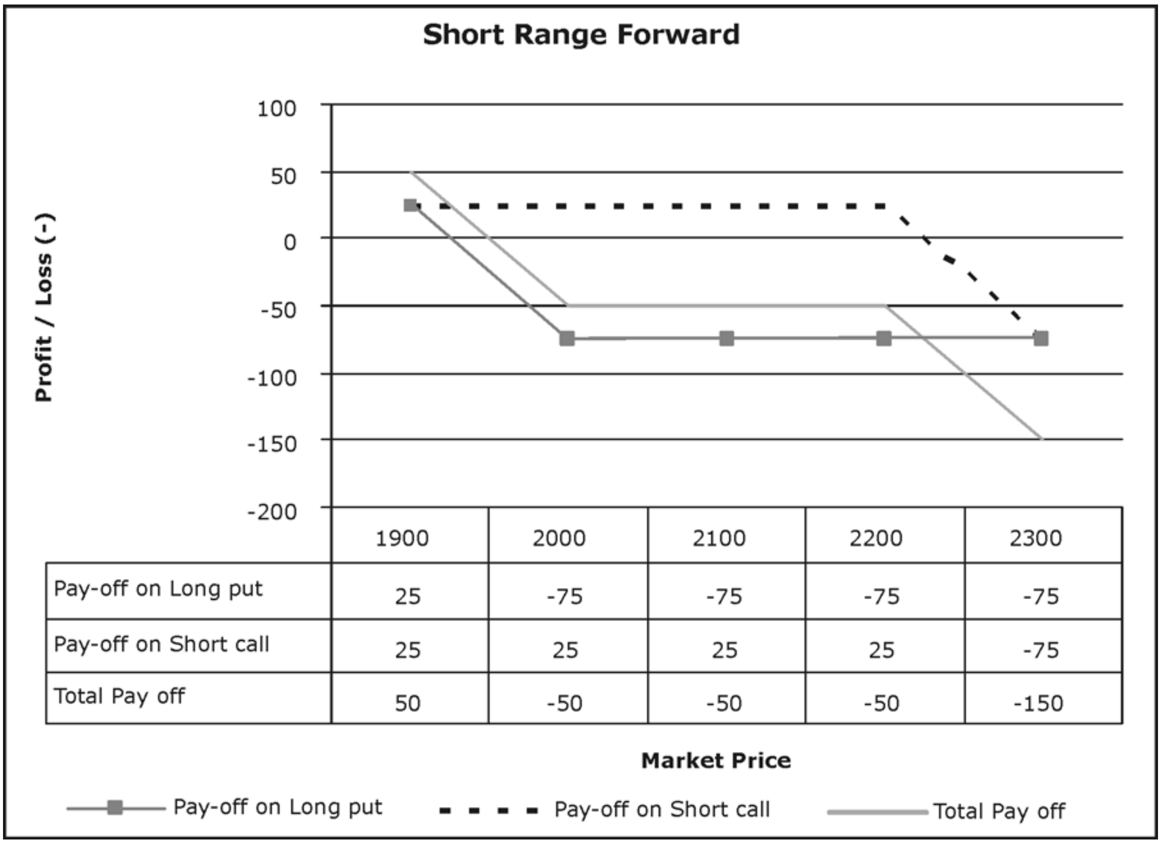
A short range forward is a combination of:

- Long position in put with strike price K_1.
- Short position in call with strike price K_2, where $K_1 < K_2$

Suppose SBI is trading at Rs. 2,025. Rs. 2,000 put for 1-month is available at Rs. 75; Rs. 2,200 call for the same maturity is available at Rs. 25.

On account of the short range forward transaction, the investor will pay net premium of (Rs. 75 – Rs. 25) i.e. Rs. 50. The pay offs are shown in Figure 8.6.

Figure 8.6



	1900	2000	2100	2200	2300
Pay-off on Long put	25	-75	-75	-75	-75
Pay-off on Short call	25	25	25	25	-75
Total Pay off	50	-50	-50	-50	-150

If the market price goes below Rs. 2,000, the investor will exercise the put. The investor will gain to the extent of (Market Price – Rs. 2,000). At a break-even price of Rs. 1,950, the gain of Rs. 50 on the short put option exercised is equal to the net premium paid when the short range forward position was initiated.

If the market price goes above Rs. 2,200, the call written by the investor will get exercised. The investor will lose to the extent of (Market Price – Rs. 2,200).

If the market price is between Rs. 2,000 and Rs. 2,200, then neither option will be exercised. The net premium of Rs. 50 paid earlier, becomes the total loss from the position.

A short range forward position is initiated when the market view is significantly bearish.

8.1.3.6. Box Spread

This is a combination of a bull spread and a bear spread, which is meaningful only for European options. The pay-off will be equal to $K_2 – K_1$ at any market price for the underlying stock.

A long box spread will entail the following trades:

- Buy a K_1 call
- Sell a K_2 call
- Buy a K_2 put
- Sell a K_1 put

A short box spread is a combination of the reverse of these four trades, viz.

- Buy a K_2 call
- Sell a K_1 call
- Buy a K_1 put
- Sell a K_2 put

8.1.3.7. Condor

This is similar to a butterfly spread. But, the two options in the middle have different strikes, instead of the single strike that is used in butterfly spread. The complete strategy therefore entails four different strikes.

Long condor is suitable when the market is expected to be range bound. Maximum profit occurs when the market price is between the two middle strikes. The profits and losses are capped.

Short condor is appropriate for volatile markets. Maximum loss occurs when the market price is between the two middle strikes. The profits and losses are capped.

8.2 Option Chain

A listing of options on the same underlying, for the same expiry, at different strike prices is called Option Chain. Table 8.1 shows the option chain on Nifty for May 31, 2012 expiry.

The following can be seen from the table:

- In the top row, towards the right, the Nifty value of 4920.40 at 3.30 pm on May 25, 2012 can be seen. This was the time a snapshot of the table was taken from the NSE website (www.nseindia.com).
- The second row shows the nature of the contract (option), underlying (Nifty) and expiry (May 31, 2012)
- The middle column shows various strike prices. Calls for each strike price are listed in the left; Puts for the same strikes are listed in the right.
- The shaded portions of the table are in the money options viz.
    - Call options at strikes below 4920.40
    - Put options at strikes above 4920.40

Table 8.1

Nifty Option Chain

Option Chain (Equity Derivatives)

Underlying Index: **NIFTY 4920.40** As on May 25, 2012 15:30:51 IST

View Options Contracts for: NIFTY OR Search for an underlying stock: GO Filter by: Expiry Date 31MAY2012 Futures contracts

CALLS												PUTS										
Chart	OI	Chng in OI	Volume	IV	LTP	Net Chng	Bid Qty	Bid Price	Ask Price	Ask Qty	Strike Price	Bid Qty	Bid Price	Ask Price	Ask Qty	Net Chng	LTP	IV	Volume	Chng in OI	OI	Chart
	-	-	-	-	-	-	1,000	1,087.30	1,572.30	500	3600.00	-	-	3.00	1,000	-	-	-	-	-	-	
	-	-	-	-	-	-	1,000	986.40	1,473.00	500	3700.00	-	-	0.25	100	-	-	-	-	-	100	
	-	-	-	-	-	-	1,000	885.50	1,373.70	500	3800.00	5,000	0.05	3.00	1,000	-	-	-	-	-	1,000	
	-	-	-	-	-	-	1,000	784.55	1,274.35	500	3900.00	5,000	0.05	3.00	1,000	-	-	-	-	-	-	
	266,850	-17,650	459	-	922.00	12.75	200	919.15	929.10	3,000	4000.00	9,750	0.15	0.20	4,750	-0.05	0.25	58.37	439	-6,200	376,700	
	2,500	-	-	-	-	-	1,000	748.65	870.95	1,000	4100.00	1,500	0.25	0.30	25,100	-0.15	0.25	52.07	239	-	143,000	
	8,550	-4,550	151	-	721.00	65.45	1,000	627.40	780.70	1,000	4200.00	3,050	0.35	0.40	5,600	-0.15	0.35	47.47	2,187	-19,650	225,450	
	43,950	-3,400	146	-	610.00	30.00	1,000	604.25	679.05	1,000	4300.00	20,000	0.35	0.50	2,800	-0.25	0.45	42.31	1,670	-30,650	623,000	
	3,150	-250	8	-	510.00	-3.70	200	520.15	535.25	1,000	4400.00	2,000	0.75	0.80	19,700	-0.50	0.70	37.89	21,368	50,600	1,516,550	
	188,100	-17,300	703	-	415.00	-0.05	150	415.20	433.85	50	4500.00	1,300	1.05	1.10	4,000	-1.05	1.05	33.02	66,945	-248,650	2,914,800	
	124,150	-13,800	1,024	-	325.00	9.50	100	322.55	335.25	4,000	4600.00	6,200	1.85	1.90	21,500	-2.25	1.85	28.65	191,785	-488,550	5,768,550	
	619,050	-311,950	14,576	-	229.00	9.75	500	226.55	229.00	350	4700.00	4,600	4.95	5.00	11,000	-5.25	4.95	25.77	273,984	352,050	9,764,800	
	2,192,050	-565,350	122,589	15.21	138.15	5.70	350	138.05	138.75	50	4800.00	250	13.90	14.00	50	-10.15	14.20	23.41	496,790	-48,750	7,846,100	
	5,165,550	589,150	567,551	18.26	65.60	-0.15	300	65.65	65.80	350	4900.00	50	39.30	39.50	250	-15.40	39.00	22.13	555,103	450,800	5,908,450	
	6,974,400	302,850	526,168	18.48	21.50	-2.50	2,700	21.50	21.55	3,700	5000.00	100	93.05	93.35	4,950	-15.95	93.35	22.11	106,638	-285,100	2,698,350	
	6,555,100	-211,150	230,785	18.89	4.85	-1.75	500	4.90	4.95	1,450	5100.00	450	175.50	178.15	200	-17.50	175.50	25.80	13,309	-15,400	2,346,100	
	6,156,600	-84,800	94,275	20.84	1.35	-0.40	1,100	1.30	1.35	7,550	5200.00	50	271.00	272.95	1,350	-14.20	273.00	30.13	5,701	-55,550	1,203,200	
	5,417,900	-61,700	44,873	24.89	0.65	-0.15	4,300	0.65	0.70	31,950	5300.00	50	370.00	373.75	4,000	-9.70	373.20	39.37	908	-4,700	817,050	
	4,022,550	-46,000	21,265	29.51	0.50	-0.15	20,200	0.50	0.55	3,150	5400.00	50	467.60	471.00	500	-4.30	474.95	47.23	360	-8,950	390,400	
	3,586,700	-31,800	5,073	33.88	0.40	-0.10	71,700	0.40	0.45	2,500	5500.00	3,500	562.95	571.00	500	-8.90	574.35	53.87	343	-10,850	452,600	
	3,754,350	-26,450	6,806	38.78	0.40	-0.10	1,700	0.40	0.45	11,350	5600.00	50	666.00	670.40	250	-14.45	670.15	58.36	336	-8,250	313,350	
	872,600	-27,850	1,355	40.96	0.25	-0.05	9,400	0.20	0.25	33,450	5700.00	5,000	737.55	769.55	2,150	-9.40	767.00	62.20	148	-2,750	263,500	

- Open Interest, change in Open Interest, Volume Traded, Implied Volatility and Bid-Ask spreads help in gauging the market. Implied Volatility was discussed in Chapter 6. The other terms are discussed in Chapter 10.
- More volume and open-interest is seen for strikes closer to 4920.40. These are the most liquid contracts with finer bid-ask spreads.
- As the strike goes down (i.e. they go more in the money), the bid and ask prices for calls increase; the bid and ask prices for puts reduce when their strike goes down (i.e. they go more out of the money).
- Through appropriate selection from the drop down menu at the top, it is possible to get similar information for other contracts and expiries.

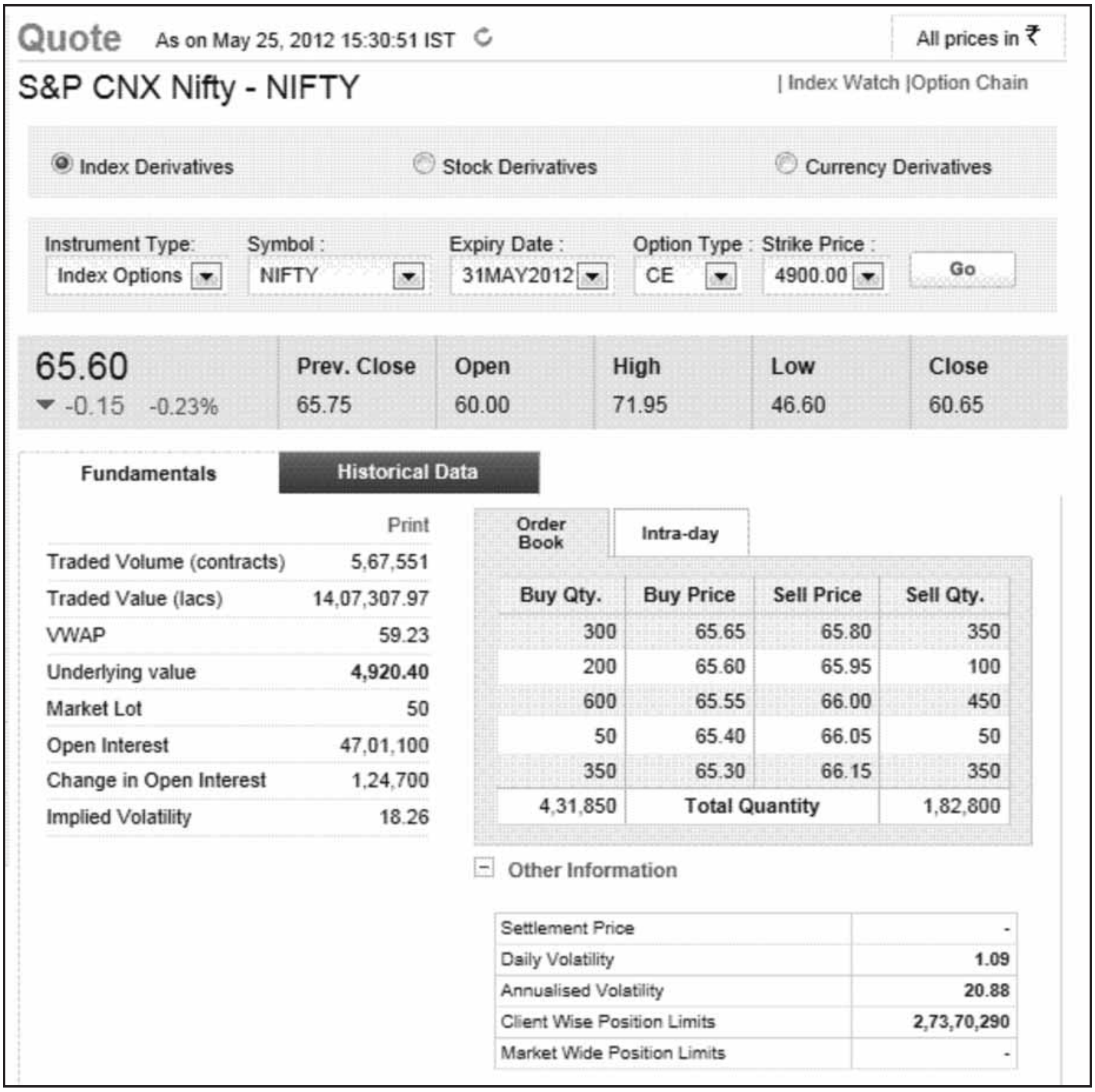
8.3 Contract Fundamentals

Further details of the specific contract are available on the Web, as seen in Table 8.2.

- **o** Instrument Type, Symbol, Expiry, Option Type and Strike Price are seen at the top of the table. The drop down box by the side of each of these fields can be used to select other contracts.
- **o** Option Type CE is a reference to European Call.
- **o** The price movement during the day is seen from the Open-High-Low-Closing details.
- **o** VWAP is a reference to the Volume Weighted Average Price for the trades done during the day.
- **o** Market Lot is 50. Thus, each contract gives exposure to the index worth 50 X 4920.40 i.e. Rs. 2,46,020.
- **o** The order book shows the depth of the market for the contract.
    - ▪ The five best buying interests in the market are shown, with the best price at the top.
    - ▪ At the best (highest) price, there is buying interest for 6 contracts i.e. 6 X 50 = 300 Nifty. Total buying interest is for 431,850 Nifty.
    - ▪ Similarly, the five best selling interests in the market are shown, with the best price at the top.
    - ▪ At the best (lowest) price, there is selling interest for 7 contacts i.e. 7 X 50 = 350 Nifty. Total selling interest is for 182,800 Nifty.
- **o** The maximum position that a single client can take in Nifty options is 2,73,70,290. There is no limit for the market as a whole. Stock options have a Market Wide Position Limit too.

- **o** The daily and annualised volatility are the historical volatility of the underlying (Nifty). These are common for all Nifty option contracts.
- **o** Implied volatility for the Nifty is based on the option price in the market for strike price = 4,900.

Table 8.2


Quote As on May 25, 2012 15:30:51 IST

All prices in ₹

S&P CNX Nifty - NIFTY

| Index Watch |Option Chain

Index Derivatives Stock Derivatives Currency Derivatives

Instrument Type: Index Options; Symbol: NIFTY; Expiry Date: 31MAY2012; Option Type: CE; Strike Price: 4900.00; Go

65.60	Prev. Close	Open	High	Low	Close
-0.15 -0.23%	65.75	60.00	71.95	46.60	60.65

Fundamentals | Historical Data

	Print
Traded Volume (contracts)	5,67,551
Traded Value (lacs)	14,07,307.97
VWAP	59.23
Underlying value	4,920.40
Market Lot	50
Open Interest	47,01,100
Change in Open Interest	1,24,700
Implied Volatility	18.26

Order Book | Intra-day

Buy Qty.	Buy Price	Sell Price	Sell Qty.
300	65.65	65.80	350
200	65.60	65.95	100
600	65.55	66.00	450
50	65.40	66.05	50
350	65.30	66.15	350
4,31,850	Total Quantity		1,82,800

Other Information

Settlement Price	-
Daily Volatility	1.09
Annualised Volatility	20.88
Client Wise Position Limits	2,73,70,290
Market Wide Position Limits	-

8.4 Option Trading Intricacies

8.4.1 Choice of Strike Price

The premia for June 28 expiry for different strike prices on SBI Calls on May 28 (when SBI was quoted at Rs. 2,117) are shown in Table 8.3.

Intrinsic value is calculated as Max (2117 – Strike, 0).

Time value is Call Premium – Intrinsic Value.

Table 8.3

SBI Options on May 28

Strike Price	Call Premium	Intrinsic Value	Time Value	Time Value % to Spot
1900	242	217	25	1.2%
2000	150	117	33	1.6%
2100	**90**	**17**	**73**	**3.4%**
2200	48	0	48	2.3%
2300	22	0	22	1.0%
2400	9	0	9	0.4%

- Lower the strike, higher the premium earned. Prima facie, it makes sense to write calls at lower prices.
- Option premium comprises intrinsic value and time value. High intrinsic value comes with deep in the money options, which are likely to be exercised by the option buyer.

  Exercise will lead to actual losses (in the case of naked calls) or opportunity losses (in the case of covered calls). Therefore, it would be more prudent to consider the Time value, rather than the option premium.

  Time value is normally the maximum for strike prices closer to the prevailing market prices. As a percentage of spot price, the yield difference between writing the call at Rs. 2,100 and Rs. 2,400 is 3% for 1 month i.e. 36% annualised. Between Rs. 2,100 and Rs. 2,000 the difference is 1.8% for 1 month i.e. 21.6% annualised.

  From the premium yield point of view, it would therefore make sense to write calls closer to the spot.
- As seen earlier, the strike also marks the point where losses start in a naked call position (or gains get capped in a covered call position). A lower strike thus increases the risk or compromises the return. It is for this reason that the view on the stock becomes an important parameter to decide the strike price. If the view is extremely bearish, then the risk of a lower strike price can be taken.

8.4.2 Choice of Expiry

The premia for different expiries for SBI 2100 Call on May 28 are shown in Table 8.4.

Longer maturities are not only less liquid, but also offer lower premium per day (though the absolute premium will be higher). Between the June and July maturity contracts, the differential in premium yield is almost 20%.

Table 8.4

SBI Options on May 28

Strike Price	Maturity	Call Premium	Days	Premium per day	%
2100	31-May-12	35	3	11.67	201.1%
2100	28-Jun-12	90	31	2.90	50.1%
2100	26-Jul-12	105	59	1.78	30.7%

In general, any option loses value with passage of time (assuming the stock price is constant). The rate of loss in value is much slower in the earlier periods of the contract, than the later periods. Therefore, it would make sense for the call writer to write options for the near month.

8.4.3 Roll Over and Covered Calls

Covered calls entail writing calls on stock that are held by the option seller. When the call option seller does not hold the stock, it is called a naked call.

The pay-off for the seller of a call (short call) was seen in Chapter 7. Higher the price of the stock, greater would be the loss on the naked call. Since there is no ceiling to a stock price, the loss on a naked call is unlimited.

In the case of a covered call, the investor has the security. Therefore, the unlimited loss problem is avoided.

A typical situation for a covered call is when a stock has good long term potential, but not much is expected in the short term. If the investor only invests in the stock, then nothing is earned from that investment in the short term. However, if a covered call is written on that stock, then additional premium is received. This will bring down the effective cost of the investment (and therefore the break-even point for the investor). So long as the stock does not go up, the call will not be exercised. The investor continues holding the stock.

Suppose an investor holds 125 shares of SBI, bought at the prevailing price of Rs. 2,115. He chooses to write a call at Rs. 2,200 for May 31 expiry, to earn option premium of Rs. 5.

What will be his position at various price points for the SBI share in future? This is detailed in Table 8.5.

Table 8.5

SBI Call Options in Various Price Scenarios

Price of SBI Share in future	Rs. 2,000	Rs. 2,200	Rs. 2,400
May 31 Rs. 2,200 call	0.05	35	225
May 31 Rs. 2,400 call	0.05	3	30
Acquisition Price	Rs. 2,115	Rs. 2,115	Rs. 2,115
Premium Received	Rs. 5	Rs. 5	Rs. 5
Breakeven Value	Rs. 2,110	Rs. 2,110	Rs. 2,110
Profit / Loss(-) on stock	-Rs. 115 (2000-2115)	Rs. 85 (2200-2115)	Rs. 85 (2400-2115)
Premium received	Rs. 5	Rs. 5	Rs. 5
Total Profit / Loss (-)	-Rs. 110	Rs. 90	Rs. 90

- If SBI shares fall in value, the call option will not be exercised. While Rs. 5 of premium was earned, the investor loses Rs. 115 on the stock. Therefore, covered calls should be written only on stocks that are unlikely to go down. A bullish view is essential.
- When the share price goes up to the exercise price of Rs. 2,200, the investor earns Rs. 85 on the stock. Along with the Rs. 5 premium earned, the total profit is Rs. 90.
- When the share price goes up to Rs. 2,400, the investor can potentially earn (Rs. 2,400 – Rs. 2115) i.e. Rs. 285 on the stock. However, the buyer of the call will exercise the option when the share prices goes above Rs. 2,200. Therefore, the investor will not be able to participate in gains in the market beyond Rs. 2,200. Covered calls should therefore be written only if the bullish view is moderate. Else, the covered call writer ends up losing on potential gains.
- What should the investor do, if he now expects the share price to go beyond Rs. 2,200? He can roll over the contract at a higher price, of say, Rs. 2,400. This would entail the following transactions:
  - Buying the Rs. 2,200 call at the prevailing price of Rs. 35. This will reverse his earlier call written position.
  - Sell the Rs. 2,400 call at the prevailing price of Rs. 3. Thus, a new call is written.
  - Net outflow for the investor on account of the roll-over would be Rs. 35 – Rs. 3 i.e. Rs. 32.

  This kind of a roll-over to a higher price is called a rolling-up. By paying Rs. 32 for the roll-up, the investor will be able to participate in profits to the extent of an additional Rs. 200 (Rs. 2,400 – Rs. 2,200).

- The outflow of Rs. 32 came up because very little was earned by selling the Rs. 2,400 Call for May 31 maturity. It is possible that at the same time, the Rs. 2,400 Call for June 28 expiry is trading at Rs. 50. An investor who chooses to write this Call will receive a net inflow of Rs. 50 – Rs. 35 i.e. Rs. 15. This kind of a roll over to a higher price for a longer maturity is called rolling-up-and-out.
- Suppose that when the share price goes down to Rs. 2,000, May 31 Rs. 2,000 call is trading at Rs. 25. What should the investor do?
  - If the expectation is that the share will go down further, then it would be better to close both positions. This would entail selling the share at Rs. 2,000 and buying the Rs. 2,200 May 31 Call at the negligible price of 5 paise.
  - If the expectation is that the share price will remain steady, then the investor can roll over the contract at a lower price, of say, Rs. 2,000. This would entail the following transactions:
    - ❖ Buying the Rs. 2,200 call at the prevailing price of Rs. 35. This will reverse his earlier call written position.
    - ❖ Sell the Rs. 2,000 call at the prevailing price of Rs. 25. Thus, a new call is written.
  - Net inflow for the investor on account of the roll-over would be Rs. 35 – Rs. 25 i.e. Rs. 10.

This kind of a roll-over to a lower price is called a rolling-down. The investor receives Rs. 10 for the roll-down. However, he will not be able to participate in profits if the market price goes above Rs. 2,000 i.e. he has given up potential profit of Rs. 200 (Rs. 2,200 – Rs. 2,000).

Points to remember

- Protective put (also called synthetic long call) is a combination of long stock and long put. Pay-off is similar to a long call.

  Breakeven selling price for the stock is the sum of cost price of the stock and the premium paid for the long call. Above breakeven, profit potential is unlimited. But loss is limited.

  This strategy is suitable when the investor is bullish about the stock, but has some concern about possible declines.

- Covered put is a combination of short stock and short put. Pay-off is similar to a short call. Pay-off is similar to a short call position.

  This strategy is suitable when the investor is moderately bearish about the stock or expects it to go side-ways. If the market goes up, losses can be unlimited.

- Covered call combines a long stock position with a short call. It is also called a buy-write strategy. Pay-off is similar to a short put.

  Breakeven point is the difference between the cost price of the stock and the premium received on the call written. If the stock goes below the breakeven point, significant losses are possible.

  This strategy is suitable when the view is moderately bullish or sideways.

- Protective call (also called synthetic long put) combines a long call with a short stock position. Pay-off is similar to a long put.

  This strategy is suitable when the view is bearish, with some concern about a potential increase.

- In a bull spread, the investor earns profits if the market is up. Since the profit from this spread is capped, the strategy is appropriate only when the market is moderately bullish. It can be built using either Calls or Puts. Accordingly, it can be a Bull Call Spread or a Bull Put Spread.

  - In a Bull Call Spread, a call option is bought and another call option sold on the same stock with the same expiry. The call option sold has a higher strike price (say, K_2) as compared to the call option bought (with exercise price of K_1).
  - In a Bull Put Spread, a put option is bought and another put option sold on the same stock with the same maturity. The put option sold has a higher strike price.

- In a bear spread, the investor earns profits if the market is down. However, since the profits are capped, this strategy is sensible only when the market is moderately bearish. As in the case of bull spread, the bear spread too, can be built using Calls or Puts. Accordingly, it can be a Bear Call Spread or a Bear Put Spread.

  - In a Bear Call Spread, a call option is bought and another call option sold on the same stock with the same expiry. The call option bought has a higher strike price (say, K_2) as compared to the call option sold (with exercise price of K_1).
  - In a Bear Put Spread, a put option is bought and another put option sold on the same stock with the same maturity. The put option sold has a lower strike price.

- Butterfly spread entails options with exercise at three different price levels, say, K_1, K_2 and K_3, with $K_1 < K_2 < K_3$ and $K_2 - K_1 = K_3 - K_2$. Typically, K_2 is near the current stock price. Butterfly spreads can be created using call or put options.

  One structure is to buy one call at K_1, another call at K_3 and sell two calls at K_2. is a long call butterfly spread. A similar pay-off is possible through a long put butterfly spread, which would entail buying a put at K_1, another put at K_3 and two puts at K_2.

The long butterfly strategy (through calls or puts) makes profits if the market is range bound. For volatile markets, the investor can reverse the above positions to do a short call butterfly or short put butterfly.

- In a calendar spread, different options of the same type but different maturities are used. The underlying and strike price are held constant.

  In a regular calendar spread, a shorter maturity call (or put) option is sold and longer maturity call (or put) option is purchased at the same strike price.

  The payoff from a regular calendar spread is similar to a long butterfly strategy – maximum when the market is range bound.

- A calendar spread is considered neutral, if the strike price is at the current market price. If the strike price is higher than the current market, it is considered to be a bullish calendar spread. Strike price lower than the current market would make it a bearish calendar spread.
- In a reverse calendar spread, the option (put or call) bought is of a shorter maturity than the option sold. Reverse calendar spread earns some profits if the market moves significantly in either direction. If the market remains range bound, significant losses are possible.
- In a diagonal spread, only the underlying is the same. Both maturity and strike price of the options used are different.
- In a long straddle, the investor buys a call and a put with the same strike price.If the stock price moves significantly in either direction, then payoff equivalent to the difference between the market price and strike price is earned. Therefore, a long straddle is suitable for volatile markets.
- In a short straddle, the investor sells a call and a put with the same strike price. A short straddle is a risky strategy, where the investor loses if the market moves in either direction. Only if the market closes at the strike price, will both options lapse.
- A strangle is slightly different from the straddle. Here, the two options bought (if it is a long strangle) or sold (if it is a short strangle) have different exercise prices.
- In a long strangle, the investor expects a significant change in market, but is not clear about the direction of the change.
- A short strangle – risky like a short straddle – is suitable when the investor expects that the market will be at or near the strike price.
- A collar is a covered call plus downside protection. In a covered call, since the investor holds the stock, a decline in market leads to a loss. To protect against such loss, the investor buys a put.

This is a conservative strategy, where both gains and losses are capped through the call and put respectively. The strategy is suitable if the market view is moderately bullish.

- A range forward is a combination of a call and a put at different strike prices but the same maturity.
- A long range forward is a combination of:
  - Short position in put with strike price K_1.
  - Long position in call with strike price K_2, where $K_1<K_2$

A long range forward position is initiated when the market view is significantly bullish.

- A short range forward is a combination of:
  - Long position in put with strike price K_1.
  - Short position in call with strike price K_2, where $K_1<K_2$

A short range forward position is initiated when the market view is significantly bearish.

- A box-spread is a combination of a bull spread and a bear spread, which is meaningful only for European options. The pay-off will be equal to $K_2 - K_1$ at any market price for the underlying stock.
- A long box spread will entail the following trades:
  - Buy a K_1 call
  - Sell a K_2 call
  - Buy a K_2 put
  - Sell a K_1 put
- A short box spread is a combination of the reverse of these four trades, viz.
  - Buy a K_2 call
  - Sell a K_1 call
  - Buy a K_1 put
  - Sell a K_2 put
- This is similar to a butterfly spread. But, the two options in the middle have different strikes, instead of the single strike that is used in butterfly spread. The complete strategy therefore entails four different strikes.
- Long condor is suitable when the market is expected to be range bound. Maximum profit occurs when the market price is between the two middle strikes. The profits and losses are capped.

- Short condor is appropriate for volatile markets. Maximum loss occurs when the market price is between the two middle strikes. The profits and losses are capped.
- A listing of options on the same underlying, for the same expiry, at different strike prices is called Option Chain.
- As the strike goes down (i.e. they go more in the money), the bid and ask prices for calls increase; the bid and ask prices for puts reduce when their strike goes down (i.e. they go more out of the money).
- Lower the strike, higher the premium earned. Prima facie, it makes sense to write calls at lower prices.
- Option premium comprises intrinsic value and time value. High intrinsic value comes with deep in the money options, which are likely to be exercised by the option buyer.
- Exercise will lead to actual losses (in the case of naked calls) or opportunity losses (in the case of covered calls). Therefore, it would be more prudent to consider the Time value, rather than the option premium.
- Time value is normally the maximum for strike prices closer to the prevailing market prices.From the premium yield point of view, it would make sense to write calls closer to the spot.
- The strike marks the point where losses start in a naked call position (or gains get capped in a covered call position). A lower strike thus increases the risk or compromises the return. It is for this reason that the view on the stock becomes an important parameter to decide the strike price. If the view is extremely bearish, then the risk of a lower strike price can be taken.
- Longer maturities are not only less liquid, but also offer lower premium per day (though the absolute premium will be higher).
- In general, any option loses value with passage of time (assuming the stock price is constant). The rate of loss in value is much slower in the earlier periods of the contract, than the later periods. Therefore, it would make sense for the call writer to write options for the near month.
- Covered calls entail writing calls on stock that are held by the option seller. When the call option seller does not hold the stock, it is called a naked call.
- Since there is no ceiling to a stock price, the loss on a naked call is unlimited.
- In the case of a covered call, the investor has the security. Therefore, the unlimited loss problem is avoided.

- A typical situation for a covered call is when a stock has good long term potential, but not much is expected in the short term.

  If the investor only invests in the stock, then nothing is earned from that investment in the short term. However, if a covered call is written on that stock, then additional premium is received. This will bring down the effective cost of the investment (and therefore the break-even point for the investor).

  So long as the stock does not go up, the call will not be exercised. The investor continues holding the stock.

- Roll-over to a higher price is called a rolling-up. It entails a cost, but lets the investor participate in profits to a greater extent.
- Roll over to a higher price for a longer maturity is called rolling-up-and-out.
- Roll-over to a lower price is called a rolling-down. The investor receives a premium for the roll-down, but ends up surrendering some profits, if the market were to go up.

Self-Assessment Questions

❖ Protective put is same as

  ➢ Synthetic long put

  ➢ **Synthetic long call**

  ➢ Covered put

  ➢ Covered call

❖ Pay-off in a covered call is similar to

  ➢ Long call

  ➢ Long stock

  ➢ **Short put**

  ➢ Short call

❖ In a bull spread, the investor makes profits if market goes

  ➢ **Up**

  ➢ Down

  ➢ Sideways

  ➢ None of the above

- Butter fly entails ________ strikes
    - 1
    - 2
    - **3**
    - 4
- In a reverse calendar spread, the option bought is of a shorter maturity than the option sold.
    - **True**
    - False
- In a diagonal spread, which of the following remains constant?
    - **Underlying**
    - Underlying & Strike
    - Underlying & Maturity
    - Underlying, Strike & Maturity

Chapter 9: Exotic Options

The options discussed in the previous chapter were standard exchange-traded puts and calls. These are traded in the F&O segment of NSE. The liquidity in these contracts comes out of standardisation of the contracts.

Investment bankers structure various Over the Counter (OTC) option products that are not traded in the exchange. In the absence of liquidity and trading, they can be quite expensive, offering enough scope for investment bankers to earn attractive margins / fees. Benefit for the clients who take exposure to such products is that some of these structures fit their specific requirements much better.

9.1 Asian Option

In the options discussed so far, the pay-off depended on the market price on maturity of the contract. In an Asian option, the pay-off depends on the average price of the underlying during the tenor of the contract, or part of the tenor of the contract.

Such a contract, with foreign currency as the underlying, offers obvious benefits to corporate treasuries that may receive / pay foreign currency at various points of time, as part of the normal business operations.

9.2 Bermudan Option

This is a variation of American options, where exercise is permitted only on specified dates. Thus, it is positioned between European options (where early exercise is not permitted) and American Options (which can be exercised any time before maturity).

9.3 Compound Option

This is an option on an option. Such options have two strike prices (K_1 and K_2) and two strike dates (T_1 and T_2).

For example, the holder of the compound option can have a right to pay K_1 at time T_1 and be entitled to another option that will entitle him to exercise the option by paying K_2 at time T_2.

Compound options can be structured in various ways – Call on Call, Call on Put, Put on Call or Put on Put.

9.4 Binary Option

This is an option where there are only two possibilities – a fixed amount (say, Q) if a condition is fulfilled; else nothing.

If the condition to be fulfilled is that the price should go above the exercise price, it is a binary call option. It will be priced as $Qe^{-rT}N(d_2)$

If the condition to be fulfilled is that the price should go below the exercise price, it is a binary put option. It will be priced as $Qe^{-rT}N(-d_2)$

Binary options structured in this fashion are also called Cash or nothing options.

Binary options can also be structured as Asset or nothing options. Here, instead of the fixed amount, Q an asset is given if the condition is fulfilled. This is like the European option already discussed. The valuation of the option would thus be driven by the value of the asset. Asset or nothing Call options are valued at $S_0e^{-qT}N(d1)$. Asset or nothing Put options are valued at $S_0e^{-qT}N(-d1)$.

9.5 Barrier Option

This is an option where the pay-off depends on whether the underlying asset reaches a specified value (the barrier) during a specified period. If the option comes into effect only if the price of the underlying reaches the barrier, it is a knock-in option. If the option ceases to exist if the price of the underlying reaches the barrier, it is a knock-out option.

9.6 Look back Option

Here, the pay-off depends on the maximum or minimum value touched by the underlying during the life of the contract.

In a look-back call, the buyer is able to acquire the asset at the lowest price it reaches during the contract period.

In a look-back put, a person holding the asset can sell it at the highest price it reaches during the contract period.

9.7 Shout Option

This is an option where once during the contract period, the holder can shout to the writer. The pay off on the long option would be its value on maturity or its value at the time of shout, whichever works better for the holder of the option.

9.8 Chooser Option

In this kind of option, the holder can decide whether to treat it as a call or a put. Its value will therefore be the higher of the call or put.

Investors need to be extra-careful with exotic options because of their non-standardisation, lack of liquidity and expensive nature.

Points to remember

- Exotic options are mostly non-standardised contracts. Investment bankers structure various Over the Counter (OTC) option products that are not traded in the exchange.
- Exotic options can be quite expensive, offering enough scope for investment bankers to earn attractive margins / fees. Benefit for the clients who take exposure to such products is that some of these structures fit their specific requirements much better.
- In an Asian option, the pay-off depends on the average price of the underlying during the tenor of the contract, or part of the tenor of the contract.
- A Bermudan option is a variation of American options, where exercise is permitted only on specified dates.
- Compound option is an option on an option. Such options have two strike prices (K_1 and K_2) and two strike dates (T_1 and T_2).
- Compound options can be structured in various ways – Call on Call, Call on Put, Put on Call or Put on Put.
- Binary option is an option where there are only two possibilities – a fixed amount (say, Q) if a condition is fulfilled; else nothing.
  - If the condition to be fulfilled is that the price should go above the exercise price, it is a binary call option. It will be priced as $Qe^{-rT}N(d_2)$
  - If the condition to be fulfilled is that the price should go below the exercise price, it is a binary put option. It will be priced as $Qe^{-rT}N(-d_2)$
- Binary options can also be structured as Asset or nothing options. Here, instead of the fixed amount, Q an asset is given if the condition is fulfilled. This is like the European option
  - Asset or nothing Call options are valued at $S_0e^{-qT}N(d1)$.
  - Asset or nothing Put options are valued at $S_0e^{-qT}N(-d1)$.
- Barrier option is an option where the pay-off depends on whether the underlying asset reaches a specified value (the barrier) during a specified period.
  - If the option comes into effect only if the price of the underlying reaches the barrier, it is a knock-in option.
  - If the option ceases to exist if the price of the underlying reaches the barrier, it is a knock-out option.

- In a look-back option, the pay-off depends on the maximum or minimum value touched by the underlying during the life of the contract.
  - In a look-back call, the buyer is able to acquire the asset at the lowest price it reaches during the contract period.
  - In a look-back put, a person holding the asset can sell it at the highest price it reaches during the contract period.
- A shout option is an option where once during the contract period, the holder can shout to the writer. The pay off on the long option would be its value on maturity or its value at the time of shout, whichever works better for the holder of the option.
- In a chooser option, the holder can decide whether to treat it as a call or a put. Its value will therefore be the higher of the call or put.
- Investors need to be extra-careful with exotic options because of their non-standardisation, lack of liquidity and expensive nature.

Self-Assessment Questions

- In __________ option, the pay-off depends on the average price of the underlying during the tenor of the contract.
  - American
  - European
  - **Asian**
  - Dutch
- Which of the following is true of compound options?
  - Based on calls or puts
  - Two strike prices
  - Two strike dates
  - **All the above**
- Which of the following is a binary option?
  - Cash or nothing
  - Stock or nothing
  - **Both the above**
  - None of the above

- Asset or nothing Put options are valued at
  - **$S_0e^{-qT}N(-d1)$**
  - $S_0e^{-qT}N(d1)$
  - $S_0e^{-qT}N(-d2)$
  - $S_0e^{-qT}N(d2)$
- Knock in option is a type of barrier option
  - **True**
  - False
- A shout option is one which is traded through open cry system in the trading floor.
  - True
  - **False**

Chapter 10: Market Indicaters

Derivative strategies are closely linked to the view on the market or the stock. Bullish markets, bearish markets, flat markets, volatile markets – each call for a different approach.

Fundamental analysis and technical analysis are two approaches to securities analysis. While the former looks at the company's fundamentals viz. product mix, business outlook, margins, management, business environment etc., the latter looks at the stock price / index movements, volumes etc.

Since the active derivative contracts are shorter term in nature, derivative strategies call for a shorter term view on the markets and stocks. Technical analysis is more amenable to such short term views.

A few market indicaters that are typically evaluated are discussed below:

10.1 Put-Call Ratio

The Put-Call Ratio is a useful tool to gauge the market pulse. It is especially useful as a lead indicater for market swings. It is calculated as the Put Trading Volume ÷ Call Trading Volume over a day or week.

NSE provides daily Market Activity Report as a download from its website (www.nseindia.com). This zip file includes several MS Excel Worksheets which provide useful data including trading volumes. Therefore, Put-Call Ratio can be easily calculated.

For example, on May 25, 2012, the put trading volume in index options was 9,87,55,790. Call trading volume in index options was 8,96,81,845. The put-call ratio amounted to (9,87,55,790 ÷ 8,96,81,845) i.e. 1.10.

The ratio for index and stock options together was (15,19,15,290 ÷ 22,02,70,970) i.e. 0.69.

Stock options alone had a Put-Call Ratio of (5,31,59,500 ÷ 13,05,89,125) i.e. 0.41.

In some markets, stock option put-call ratio is given greater importance because portfolio managers use index options to hedge their portfolios. Since hedging volume is not necessarily indicative of any market trend, index option put-call ratio can be misleading. However, where stock options are not so liquid, index option based put-call ratios represent a better compromise.

Traders look for changes in trend to form an opinion on the likely direction of the market / stock. 10-day exponential moving average charts of the put-call ratio can be used to study the trend.

Put contracts make money when the market is in a decline. Therefore, higher volume of put contracts (which would translate into a higher put-call ratio) is indicative that the market expects a decline in the market / stock. For the same reason, higher volume of call contracts (which would translate into a lower put-call ratio) indicates a market expectation of an upward trend in the market / stock.

It the market is otherwise bullish, then a decline in call contracts / increase in put contracts / increase in put-call ratio is a signal that the market may change direction. Similarly, if the market is otherwise bearish, then an increase in call contracts / decrease in put contracts / decrease in put-call ratio is indicative of a likely change in the direction of the market.

10.2 Open Interest

A position is initiated through a purchase or sale of a put or call. This creates an open interest. When the position is reversed through a sale or purchase of a put or call on the same underlying, the open interest is reduced. Open interest also gets reduced when an option buyer exercises the option / the exchange assigns the exercise to a counter party who has an open position. Open interest thus represents all the positions that have been initiated but not reversed / exercised / assigned.

One interpretation of open interest relates to the depth of the market for that contract. A large open interest means that the contract is liquid. Liquid contracts tend to have narrower bid-ask spreads and are therefore friendly towards market participants.

Change in open interest provides information on whether new positions are being created, or whether positions are being unwound. Closer to the last Thursday of the month (when the contracts mature), one sees a lot of unwinding of contracts.

Together with trading volume, open interest helps judge the level of activity. For example, if trading volume is 200,000, while open interest is only 150,000, then it means that the contract was very actively traded during the day.

In general, an uptrend in prices, together with rise in trading volumes and open interest is a bullish signal. It indicates that more money is coming into the market.

Higher prices with declining trading volumes and open interest are indicative of a weak market, where money is going out. The price increase may be only on account of short-sellers covering their position.

Decline in prices, together with rise in trading volumes and open interest is a bearish indicater. However, if the decline in prices comes with declining trading volumes and open interest, then the market is likely to reverse.

NSE provides information on open interest for each broad contract type (futures, index call options, index put options, stock call options, stock put options) separately for Domestic

Institutional Investors, Foreign Institutional Investors and other proprietary / client positions. Thus, it becomes possible to assess how each investor type is viewing the market.

10.3 Roll-over

As an options contract approaches maturity, investors either let it lapse, or exercise it at the strike price. As discussed in Chapter 4, the possibility of exercise depends on the nature of the contract and potential dividend payments during the tenor of the contract.

Investors may also choose to roll-over their contract by reversing their current position and getting into a new position on the same underlying for the next maturity. For example, someone who has a long call on the Nifty for May 31 maturity, will sell a long call on the Nifty (to square off the earlier position) and buy a call on the Nifty for June 28 maturity (to create a fresh position).

A large percentage of roll overs indicates that the market participants expect the trend to continue. Fewer roll overs indicate a trend reversal. The market participants are closing out their positions and not getting into fresh positions.

A proxy for the roll over in the near month is the percentage of the middle month open position to the total open position for near month, middle month and far month. For example, if open interest in a stock is as follows:

Near month (May 31 expiry)	110,000
Middle month (June 28 expiry)	250,000
Far month (July 26 expiry)	40,000

Roll over is 250,000 ÷ (110,000 + 250,000 + 40,000) i.e. 62.5%.

10.4 Volatility

If the historical volatility, as well as the volatility implied from option contracts are low, then it means that the market trend is likely to continue.

Volatility indices are a measure of market's expectation of future volatility. India VIX is a volatility index based on the NIFTY Index Option prices. From the best bid-ask prices of NIFTY Options contracts a volatility figure (%) is calculated. This indicates the expected market volatility over the next 30 calendar days. India VIX uses the computation methodology of CBOE, with suitable amendments to adapt to the NIFTY options order book. The formula used for the calculation is as follows:

$$\sigma = \frac{2}{T}\sum \frac{\Delta K_i}{K_i^{\,2}} e^{RT}\ Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]2$$

Where,

T is Time to Expiration

K_i is the strike price of i^{th} out-of-the-money option; a call if Ki > F and a put if Ki < F

ΔK_i is the interval between strike prices- half the distance between the strike on either side of K_i

R is the Risk-free interest rate to expiration

$Q(K_i)$ is the mid-point of the bid-ask quote for each option contract with strike K_i

F is the Forward index taken as the latest available price of NIFTY future contract of corresponding expiry

K_0 is the first strike below the forward index level, F.

[“VIX” is a trademark of Chicago Board Options Exchange, Incorporated (“CBOE”) and Standard & Poor’s has granted a license to NSE, with permission from CBOE, to use such mark in the name of the India VIX and for purposes relating to the India VIX.]

Points to remember

- Since the active derivative contracts are shorter term in nature, derivative strategies call for a shorter term view on the markets and stocks. Technical analysis is more amenable to such short term views.
- The Put-Call Ratio is a useful tool to gauge the market pulse. It is especially useful as a lead indicater for market swings. It is calculated as the Put Trading Volume ÷ Call Trading Volume over a day or week.
- In some markets, stock option put-call ratio is given greater importance because portfolio managers use index options to hedge their portfolios. Since hedging volume is not necessarily indicative of any market trend, index option put-call ratio can be misleading. However, where stock options are not so liquid, index option based put-call ratios represent a better compromise.
- Traders look for changes in trend to form an opinion on the likely direction of the market / stock. 10-day exponential moving average charts of the put-call ratio can be used to study the trend.
- Higher volume of put contracts (which would translate into a higher put-call ratio) is indicative that the market expects a decline in the market / stock. For the same reason, higher volume of call contracts (which would translate into a lower put-call ratio) indicates a market expectation of an upward trend in the market / stock.
    - It the market is otherwise bullish, then a decline in call contracts / increase in

put contracts / increase in put-call ratio is a signal that the market may change direction.

- **o** Similarly, if the market is otherwise bearish, then an increase in call contracts / decrease in put contracts / decrease in put-call ratio is indicative of a likely change in the direction of the market.

- Open interest represents all the positions that have been initiated but not reversed / exercised / assigned.
- A large open interest means that the contract is liquid. Liquid contracts tend to have narrower bid-ask spreads and are therefore friendly towards market participants.
- Change in open interest provides information on whether new positions are being created, or whether positions are being unwound. Closer to the last Thursday of the month (when the contracts mature), one sees a lot of unwinding of contracts.
- Together with trading volume, open interest helps judge the level of activity.
- In general, an uptrend in prices, together with rise in trading volumes and open interest is a bullish signal. It indicates that more money is coming into the market.
- Higher prices with declining trading volumes and open interest are indicative of a weak market, where money is going out. The price increase may be only on account of short-sellers covering their position.
- Decline in prices, together with rise in trading volumes and open interest is a bearish indicater. However, if the decline in prices comes with declining trading volumes and open interest, then the market is likely to reverse.
- Investors may also choose to roll-over their contract by reversing their current position and getting into a new position on the same underlying for the next maturity.
- A large percentage of roll overs indicates that the market participants expect the trend to continue. Fewer roll overs indicate a trend reversal. The market participants are closing out their positions and not getting into fresh positions.
- A proxy for the roll over in the near month is the percentage of the middle month open position to the total open position for near month, middle month and far month.
- If the historical volatility, as well as the volatility implied from option contracts are low, then it means that the market trend is likely to continue.
- Volatility indices are a measure of market's expectation of future volatility. India VIX is a volatility index based on the NIFTY Index Option prices.

From the best bid-ask prices of NIFTY Options contracts a volatility figure (%) is calculated. This indicates the expected market volatility over the next 30 calendar days.

- India VIX uses the computation methodology of CBOE, with suitable amendments to adapt to the NIFTY options order book. The formula used for the calculation is as follows:

$$\sigma = \frac{2}{T}\sum \frac{\Delta K_i}{{K_i}^2} e^{RT} \; Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]2$$

Self-Assessment Questions

❖ Put-Call ratio is used as a lead indicater of market swings.

➢ **True**

➢ False

❖ Higher put-call ratio is indicative that the market expects ________ in the market / stock.

➢ Increase

➢ **Decrease**

➢ Sideways movement

➢ None of the above

❖ Increase in put-call ratio in a bullish market is an indication of trend reversal.

➢ **True**

➢ False

❖ In general, an uptrend in prices, together with rise in trading volumes and open interest is a ________ signal.

➢ Bearish

➢ **Bullish**

➢ Mixed

➢ Weak

❖ A large percentage of roll overs indicates that the market participants expect the trend to continue.

➢ **True**

➢ False

- The near month, middle month and far month open positions are 100, 200 and 300. What is the roll-over?
  - **One-third**
  - One-half
  - One-fourth
  - Two-third
- India VIX indicates the ________ volatility.
  - Historic
  - Implied
  - **Expected Market**
  - Best case

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