NCFM

NSE's CERTIFICATION IN FINANCIAL MARKETS

Derivatives (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 * [Please refer to footnote no. (i)]	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	Technical Analysis Module	1686	120	60	100	60	5
14	Financial Markets (Advanced) Module	1686	120	60	100	60	5
15	Securities Markets (Advanced) Module	1686	120	60	100	60	5
16	Mutual Funds (Advanced) Module	1686	120	60	100	60	5
17	Banking Sector Module	1686	120	60	100	60	5
18	Insurance Module	1686	120	60	100	60	5
19	Macroeconomics for Financial Markets Module	1686	120	60	100	60	5
20	Mergers and Acquisitions Module	1686	120	60	100	60	5
21	Back Office Operations Module	1686	120	60	100	60	5
22	Wealth Management Module	1686	120	60	100	60	5
23	Project Finance Module	1686	120	60	100	60	5
24	NISM-Series-I: Currency Derivatives Certification Examination *	1250	120	100	100	60	3
25	NISM-Series-II-A: Registrars to an Issue and Share Transfer Agents – Corporate Certification Examination	1250	120	100	100	50	3
26	NISM-Series-II-B: Registrars to an Issue and Share Transfer Agents – Mutual Fund Certification Examination	1250	120	100	100	50	3
27	NISM-Series-III-A: Securities Intermediaries Compliance (Non-Fund) Certification Examination	1250	120	100	100	60	3
28	NISM-Series-IV: Interest Rate Derivatives Certification Examination	1250	120	100	100	60	3
29	NISM-Series-V-A: Mutual Fund Distributors Certification Examination *	1250	120	100	100	50	3
30	NISM Series-V-B: Mutual Fund Foundation Certification Examination	1000	120	50	50	50	3
31	NISM-Series-VI: Depository Operations Certification Examination	1250	120	100	100	60	3
32	NISM Series VII: Securities Operations and Risk Management Certification Examination	1250	120	100	100	50	3
33	NISM-Series-VIII: Equity Derivatives Certification Examination	1250	120	100	100	60	3
34	NISM-Series-IX: Merchant Banking Certification Examination	1405	120	100	100	60	3
35	NISM-Series-XI: Equity Sales Certification Examination	1405	120	100	100	50	3
36	NISM-Series-XII: Securities Markets Foundation Certification Examination	1405	120	100	100	60	3
37	Certified Personal Financial Advisor (CPFA) Examination	4495	120	80	100	60	3
38	NSDL–Depository Operations Module	1686	75	60	100	60 #	5
39	Commodities Market Module	2022	120	60	100	50	3
40	Surveillance in Stock Exchanges Module	1686	120	50	100	60	5
41	Corporate Governance Module	1686	90	100	100	60	5
42	Compliance Officers (Brokers) Module	1686	120	60	100	60	5
43	Compliance Officers (Corporates) Module	1686	120	60	100	60	5
44	Information Security Auditors Module (Part-1)	2528	120	90	100	60	2
	Information Security Auditors Module (Part-2)	2528	120	90	100	60	
45	Options Trading Strategies Module	1686	120	60	100	60	5
46	Options Trading (Advanced) Module	1686	120	35	100	60	5
47	FPSB India Exam 1 to 4**	2247 per exam	120	75	140	60	NA
48	Examination 5/Advanced Financial Planning **	5618	240	30	100	50	NA
49	Equity Research Module ##	1686	120	65	100	55	2
50	Issue Management Module ##	1686	120	80	100	55	2
51	Market Risk Module ##	1686	120	40	65	60	2
52	Financial Modeling Module ###	1123	120	30	100	50	NA
53	Financial Services Foundation Module ###	1123	120	45	100	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 Modules of Financial Planning Standards Board India, Finitiatives Learning India Pvt. Ltd. and IMS Proschool) is available on our website: www.nseindia.com > Education > Certifications.

Note: (i) NISM has specified the NISM-Series-VIII-Equity Derivatives Certification Examination as the requisite standard for associated persons functioning as approved users and sales personnel of the trading member of an equity derivatives exchange or equity derivative segment of a recognized stock exchange.

Derivatives (Advanced) Module

Background

NCFM's workbook titled Options Trading Strategies module lists various strategies for trading options, discusses their suitability in various market scenarios and the consequent pay-off matrices. NCFM's workbook titled Options Trading (Advanced) module gets into some of the quantitative aspects of options including the option greeks.

This workbook builds on those modules to discuss advanced topics in derivatives.

Learning Objectives

- To have advanced knowledge of various derivative products underlying as equities, interest rates, credit and currencies and embedded debt instruments
- To calculate and interpret beta, R-square and volatility
- To understand normal and log normal distributions and their relevance to the capital market
- To apply advanced techniques of valuation of securities and derivative products
- To know the contract structure of equity futures, criteria for selection of stocks and indices for derivatives contracts, and how margins are calculated
- To understand the concepts of cost of carry, arbitrage, contango and backwardation
- To know about conversion factor and cheapest to delivery in interest rate futures
- To know how to calculate Black Scholes options prices and the option greeks
- To understand investment and hedging strategies using equity futures, equity options, interest rate futures, currency futures, currency options and swaps and credit default swaps.

CONTENTS

Note:

- Annexure 1 (Normal Distribution Table) and Annexure 2 (Important Formulae) will be made available at the time of the test.
- Open Office application will be provided at the test centre during the test.

Distribution of weights of the Derivative (Advanced) Module Curriculum

Chapter No.	Title	Weights (%)
1	Derivatives & Quantitative Fundamentals	22
2	Fundamentals of Equity Futures	18
3	Investment with Equity Futures	5
4	Interest Rate Futures	12
5	Black-Scholes Option Pricing Model	5
6	Option Greeks	2
7	Currency Futures & Options	5
8	Swaps	11
9	Embedded Options	9
10	Credit Risk & Derivatives	6
	Valuation calculation based on Chapters 6 or 7	5
	Total	**100**

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, Advantage India Consulting Pvt. Ltd.

Chapter 1 Derivatives & Quantitative Fundamentals – 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. One party's profit from futures is the other party's losses. The pay offs in a futures contract are *symmetric.*
- *Options* are contracts where only one party (*writer* / *seller*) is committed. The other party (*holder* / *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 holder pays the option writer an *option premium* for entering into the contract.

  Unlike futures, the pay offs in an option contract are *asymmetric*. The downside for the option holder 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 to the underlying asset in the derivative market, than in the underlying cash market. This makes it attractive for speculaters and hedgers, besides normal investors.

1.2 Beta

The relation between the price of an equity share and a diversified equity index is captured by its Beta. This is calculated by examining the historical returns from the equity share and a diversified equity index over a long period of time (say, daily returns over 3 years). Thereafter, the 'slope' function can be used in MS Excel to determine the beta.

As an illustration, the calculation is shown in Table 1.1 based on returns for a very short period of 5 trading days.

<u>Table 1.1</u>

Calculation of Beta

B68 fx =SLOPE(E63:E66,D63:D66)

	A	B	C	D	E	F	G
60							
61	Day	Nifty	Share Price	Nifty Return	Share Return		
62	1	5000	50.00				
63	2	5200	52.00	4.0%	4.0%		
64	3	5100	51.50	-1.9%	-1.0%		
65	4	5075	52.20	-0.5%	1.4%		
66	5	5060	51.60	-0.3%	-1.1%		
67							
68	**Beta**	0.84					

1.3 R-Square

The reliability of the beta calculation is assessed through its R-square value. A higher value of R-square indicates that the relationship is indeed strong. If the calculated R-square value is below 50%, then the relationship is considered suspect.

R-square can be calculated using the 'RSQ' function, as illustrated in Table 1.2 for the same data.

The R-square value of 0.79 means, that 79% of the returns in the stock can be explained by returns in the index. The remaining 21% of the variation in stock returns is on account of factors other than the index.

The calculations in Tables 1.1 and 1.2 are illustrative. Beta and R-square are calculated based on data over a long period of time, say 2 – 3 years. At least 30 observations are required for a normal distribution.

Table 1.2

Calculation of R-Square

B70 =RSQ(E63:E66,D63:D66)

	A	B	C	D	E	F
60						
61	Day	Nifty	Share Price	Nifty Return	Share Return	
62	1	5000	50.00			
63	2	5200	52.00	4.0%	4.0%	
64	3	5100	51.50	-1.9%	-1.0%	
65	4	5075	52.20	-0.5%	1.4%	
66	5	5060	51.60	-0.3%	-1.1%	
67						
70	R-square	0.79				
71						

1.4 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.

More frequent compounding increases the terminal value (Rs. 5,073.37 as compared to Rs. 5,075.57).

A corollary of the above formula is

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

1.5 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), but not negative. 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 of a put would be equivalent to(K – S_0), but not negative. 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 1.3.

Table 1.3

Option Valuation Parameters

Parameter	Impact on Option Valuation if 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* (i.e. exercise price below spot price). If it is *out of the money* (i.e. exercise price above spot price), then lower the probability of it becoming in the money and therefore lower the value of the option.
- 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 profit; 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 call option.
- As compared to a direct sale of the underlying security, money comes in later (that too if the put on that security is exercised). Higher the interest rate, greater the opportunity cost of money. Therefore, higher the interest rate, less valuable the put option.
- After a stock dividend (which will go to the person holding the stock), the stock price corrects downwards. This will reduce the intrinsic value of a call option and increase the intrinsic value of a put option.

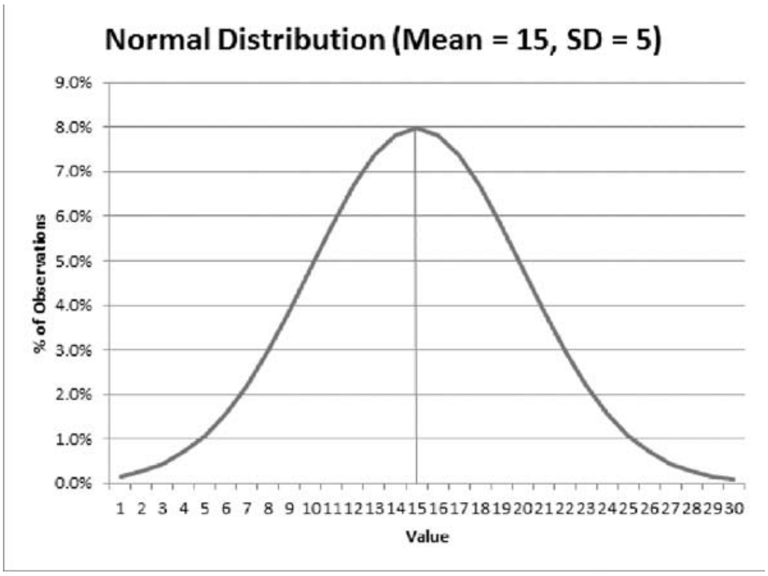
Binomial and Black Scholes are two approaches to option valuation. These were discussed in Chapters 3 and 4 respectively of NCFM's workbook titled "Options Trading (Advanced) module". Black Scholes has its inaccuracies, but is less cumbersome to apply than Binomial. A brief discussion on Black Scholes Option Pricing Model and the option Greeks is featured in Chapters 5 and 6 of this Workbook.

1.6 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 1.1.

Figure 1.1



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:
    - o 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.
    - o 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.
    - o 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:
  - o Mean ± 1 Standard Deviation covers 68.27% of the area under the curve.
  - o Mean ± 2 Standard Deviation covers 95.45% of the area under the curve.
  - o Mean ± 3 Standard Deviation covers 99.73% of the area under the curve.

1.6.1 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.

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.

1.6.2 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. There are various facets to volatility.

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 1.4.

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

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

$$i.e. \sqrt{\{1 \div (14) \times 0.0023\} - \{1 \div 210 \times (0.392)^2\}}$$

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 ÷ $\sqrt{2 \times 15}$

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

Table 1.4

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

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

2. ARCH(m) Model

The calculation in Table 1.4 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:

$$\sigma_n{}^2 = \sum_{i=1}^{m} \propto_i \mu^2{}_{n-i}$$

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

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

$$\sigma_n{}^2 = \gamma V_L + \sum_{i=1}^{m} \propto_i \mu^2{}_{n-i}$$

with $\Upsilon + \sum_{i=1}^{m} \propto_{i=1}$

γV_L can be written as ω

Thus, $\sigma_n{}^2 = \omega + \sum_{i=1}^{m} \propto_i \mu^2{}_{n-i}$

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

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 3 variables i.e.λ, σ_{n-1} and μ_{n-1}.

Suppose, constant factor, λ = 0.94, volatility estimate for yesterday, σ_{n-1}= 0.02 and change in value of the asset yesterday, μ_{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 can be calculated in MS Excel as SQRT(0.000526) i.e. 2.29%

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

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. 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 $\beta = \lambda$.

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 affects 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 estimation of any market participant, because of differences in the parameters used by various market participants.

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.

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 2 Fundamentals of Equity Futures

2.1 Contracts

The National Stock of Exchange's Futures & Options (F&O) segment provides a platform for trading in both futures & options, on select indices & stocks. The F&O segment is part of NSE's fully automatic screen-based trading system, 'National Exchange for Automated Trading' (NEAT).

NSE uses the descripters 'FUT' for futures, 'OPT' for options, 'IDX' for index and 'STK' for stocks. Accordingly, the following descripters are prevalent in the F&O segment:

- FUTIDX – Index futures
- FUTSTK – Stock futures
- OPTIDX – Index Options
- OPTSTK – Stock Options

Apart from a few longer term contracts, contracts are available in a 3-month trading cycle viz. near month (1 month), next month (2 months) and far month (3 months). They expire on the last Thursday of the relevant month. If the last Thursday is a trading holiday, then they expire on the previous trading day.

A new contract is introduced on the trading day following the expiry of the near month contract. The new contract is introduced for 3-month duration (i.e. it becomes a far month contract). The previous period's far month contract will now be the next month contract; the previous period's next month contract will now be the near month contract. Thus, the 3-month trading cycle is maintained, as shown in Table 2.1:

Table 2.1

3-Month Contracts

Contract	Expiry (Feb 1 – 28, 2013)	Expiry (Mar 1 –28, 2013)
Near Month	Feb 28, 2013	Mar 28, 2013
Next Month	Mar 28, 2013	Apr 25, 2013
Far Month	Apr 25, 2013	May 30, 2013

At the time of introduction, the contract has to have a value of at least Rs. 2 lakh, as per SEBI regulations. For example, the market lot (contract multiplier) for Futures on Nifty Index is 50. At the Nifty Index value of 6,000, the value of the futures contract on the Nifty Index would be 50 X 6,000 i.e. Rs. 3 lakh.

On the NSE, futures are available on:

- 6 domestic indices (CNX Nifty Index, CNX IT index, Bank Nifty Index, Nifty Midcap 50 index, CNX PSE and CNX Infra);
- 3 international indices (Dow Jones Industrial Average, S&P 500 and FTSE 100; and
- 149 domestic securities.

2.2 Selection Criteria

SEBI has issued guidelines for selection of indices and stocks on which derivative contracts (futures and options) can be offered for trading. Based on this, NSE has laid down the following criteria:

2.2.1 Stock Selection Criteria

- The stock shall be chosen from amongst the top 500 stocks in terms of average daily market capitalisation and average daily traded value in the previous six months on a rolling basis.
- The stock's median quarter-sigma order size over the last six months shall be not less than Rs. 10 lakhs. For this purpose, a stock's quarter-sigma order size shall mean the order size (in value terms) required to cause a change in the stock price equal to one-quarter of a standard deviation.
- The market wide position limit in the stock shall not be less than Rs. 300 crores. The market wide position limit (number of shares) shall be valued taking the closing prices of stocks in the underlying cash market on the date of expiry of contract in the month.

  The market wide position limit of open position (in terms of the number of underlying stock) on F&O contracts on a particular underlying stock shall be 20% of the number of shares held by non-promoters in the relevant underlying security i.e. free-float holding.

2.2.2 Criteria for Continued Eligibility of Stock

For an existing F&O stock, the continued eligibility criteria is that market wide position limit in the stock shall not be less than Rs. 200 crores and stock's median quarter-sigma order size over the last six months shall not be less than Rs. 5 lakhs.

Additionally, the stock's average monthly turnover in derivative segment over last three months shall not be less than Rs. 100 crores.

If an existing security fails to meet the eligibility criteria for three months consecutively, then no fresh month contract shall be issued on that security. However, the existing unexpired contracts may be permitted to trade till expiry and new strikes may also be introduced in the existing contract months.

A stock which has remained subject to a ban on new position for a significant part of the month consistently for three months, shall be phased out from trading in the F&O segment.

Further, once the stock is excluded from the F&O list, it shall not be considered for re-inclusion for a period of one year.

2.2.3 Criteria for Re-inclusion of Excluded Stocks

A stock which is excluded from derivatives trading may become eligible once again. In such instances, the stock is required to fulfil the eligibility criteria for three consecutive months, to be re-introduced for derivatives trading.

2.2.4 Index Selection Criteria

- F&O contracts on an index can be introduced only if 80% of the index constituents are individually eligible for derivatives trading. However, no single ineligible stock in the index shall have a weightage of more than 5% in the index. The index on which futures and options contracts are permitted shall be required to comply with the eligibility criteria on a continuous basis.

  SEBI has permitted the Exchange to consider introducing derivative contracts on an index if the stocks contributing to 80% weightage of the index are individually eligible for derivative trading. However, no single ineligible stocks in the index shall have a weightage of more than 5% in the index.
- The above criteria is applied every month, if the index fails to meet the eligibility criteria for three months consecutively, then no fresh month contract shall be issued on that index, However, the existing unexpired contacts shall be permitted to trade till expiry and new strikes may also be introduced in the existing contracts.

2.3 Price Steps and Price Bands for Contracts

Price of futures contracts in the market is set in multiples of Rs. 0.05.

There are no day minimum/maximum price ranges applicable in the derivatives segment. However, in order to prevent erroneous order entry, operating ranges and day minimum/ maximum ranges are kept as below:

- For Index Futures: at 10% of the base price
- For Futures on Individual Securities: at 10% of the base price

Orders placed at prices which are beyond the operating ranges would reach the Exchange as a price freeze. In respect of orders which have come under price freeze, members are required to confirm to the Exchange that there is no inadvertent error in the order entry and that the order is genuine. On such confirmation the Exchange may approve such order.

2.4 Quantity Freeze for Futures Contracts

NSE has set quantity freeze limits for various contracts. For example, the quantity freeze limit for Futures on CNX Nifty is 15,000.

In respect of orders which have come under quantity freeze, members are required to confirm to the Exchange that there is no inadvertent error in the order entry and that the order is genuine. On such confirmation, the Exchange may approve such order.

However, in exceptional cases, the Exchange may, at its discretion, not allow the orders that have come under quantity freeze for execution for any reason whatsoever including non-availability of turnover / exposure limit. In all other cases, quantity freeze orders shall be cancelled by the Exchange.

2.5 Novation

All trades executed on the NSE are guaranteed by The National Securities Clearing Corporation Ltd. (NSCCL), a wholly owned subsidiary of NSE. While a trade may be executed based on quotes of two independent parties in NEAT, NSCCL introduces itself as a party between the two independent parties, through a process called "novation". Thus, the exposure of either independent party is to NSCCL. This ensures that even if one of the counter-parties does not meet its obligation, NSCCL will settle the obligation to the other counter-party.

2.6 Margins

One of the tools through which NSCCL protects itself from default by either party, is margin payments. These are collected from both parties to the futures contract. NSCCL collects the requisite margins from Clearing Members, who will collect it from Trading Members who in turn will collect from the client.

The margin payments are based on Standard Portfolio Analysis of Risk (SPAN)®, a registered trademark of the Chicago Mercantile Exchange. It is a highly sophisticated, value-at-risk methodology that calculates performance bond/ margin requirements by analyzing the "what-if's" of virtually any market scenario. The margins are monitored on-line on intra-day basis.

The following types of margins are prevalent:

- *Initial Margin*

This is based on 99% value at risk over a two-day time horizon.

- *Exposure Margin*

  This is calculated on index futures at 3% of the notional value of a futures contract.

  On stock futures, it is the higher of 5% or 1.5 standard deviation of the notional value of gross open position. The standard deviation of daily logarithmic returns of prices in the underlying stock in the cash market in the last six months is computed on a rolling and monthly basis at the end of each month.

  Notional value means the contract value at last traded price/ closing price.

  Purchase of a futures contract for one month, and sale of futures contract on the same underlying for another month is called "calendar spread". In case of calendar spread positions in futures contract, exposure margins are levied on one third of the value of open position of the far month futures contract. The calendar spread position is granted calendar spread treatment till the expiry of the near month contract.

The initial and exposure margin is payable upfront by Clearing Members. Margins can be paid by members in the form of Cash, Bank Guarantee, Fixed Deposit Receipts and approved securities.

Clearing members who are clearing and settling for other trading members can specify in the NEAT system, the maximum collateral limit towards initial margins, for each trading member and custodial participant clearing and settling through them.

Such limits can be set up by the clearing member, through the facility provided on the trading system upto the time specified in this regard. Such collateral limits once set are applicable to the trading members/custodial participants for that day, unless otherwise modified by the clearing member.

2.7 Daily Mark-to-Market Settlement

The positions in the futures contracts for each member are marked-to-market to the daily settlement price of the futures contracts at the end of each trade day.

The profits/ losses are computed as the difference between the trade price or the previous day's settlement price, as the case may be, and the current day's settlement price.

The Clearing Members who have suffered a loss are required to pay the mark-to-market loss amount to NSCCL which is passed on to the members who have made a profit. This is known as daily mark-to-market settlement.

Clearing Members are responsible to collect and settle the daily mark to market profits/ losses incurred by the Trading Members and their clients clearing and settling through them.

The pay-in and pay-out of the mark-to-market settlement is on T+1 days (T = Trade day). The mark to market losses or profits are directly debited or credited to the Clearing Member's clearing bank account.

Clearing members may opt to pay daily mark to market settlement on a T+0 basis. The option can be exercised once in a quarter (Jan-March, Apr-June, Jul-Sep & Oct-Dec). The option once exercised shall remain irrevocable during that quarter.Clearing members who opt for payment of daily MTM settlement amount on a T+0 basis are not levied scaled up margins (higher MTM margins that are collected on the same day during extreme movements in the market).

2.8 Final Settlement

On the expiry of the futures contracts, NSCCL marks all positions of a Clearing Member to the final settlement price and the resulting profit / loss is settled in cash.

The final settlement of the futures contracts is similar to the daily settlement process except for the method of computation of final settlement price. The final settlement profit / loss is computed as the difference between trade price or the previous day's settlement price, as the case may be, and the final settlement price of the relevant futures contract.

Final settlement loss/ profit amount is debited/ credited to the relevant Clearing Members' clearing bank account on T+1 day (T= expiry day).

Open positions in futures contracts cease to exist after their expiration day.

2.9 Cost of Carry

Suppose shares of Reliance[1] are trading at Rs. 851.30 on March 8, 2013. On the same day, Reliance Futures with expiry on March 28, 2013 are trading at Rs. 854.70. If an investor is bullish on Reliance, and can borrow unlimited money at 6% p.a., will he buy in the cash market or the futures market? (Assume no margin payments)

If the investor were to buy in the cash market, and make payment by borrowing at 6% for 20 days (March 8 to March 28). The interest cost would be Rs. 851.30 X 6% X 20/365 i.e. Rs. 2.80. The total acquisition cost would thus be Rs. 851.30 + Rs. 2.80 i.e. Rs. 854.10.

If the futures are available at a price lower than Rs. 854.10, then it would make sense to take the position in Reliance in the futures market. (The calculations are refined in the next section, to arrive a break-even futures price of Rs. 854.05)

Since Reliance Futures are quoting at a higher price of Rs. 854.70, the investor would be better off by buying in the cash market.

The risk-free rate of interest that equates the cash price to the futures price is the cost of carry. Drawing on the calculations in Chapter 1,

FP = S_0 X $(1+r)^t$

Where,

FP = Futures Price (say, Rs.854.70)

S_0 = Spot Price (say, Rs. 851.30)

t = number of days (say 20÷365 years)

r = cost of carry

Substituting the previous values of Reliance, we get

854.70 = 851.30 X $(1+r)^{(20\div 365)}$

i.e. r = $(854.70 \div 851.30)^{(365\div 20)} - 1$

i.e. 7.55%

2.10 Determining Stock Futures Price (without Dividend)

Suppose shares of Reliance are trading at Rs. 851.30 on March 8, 2013. If cost of carry is 6% p.a. on discrete basis, what would be the calculated value of Reliance Futures contract with expiry on March 28, 2013?

FP = S_0 X $(1+r)^t$

= 851.30 X $(1+6\%)^{(20\div 365)}$

= Rs. 854.05 (rounded to multiple of 0.05)

This calculated price is the "no arbitrage" price, where the investor is neutral between buying in the cash market and futures market.

2.11 Determining Stock Futures Price (with Dividend)

In the same example, let us now suppose that Reliance is expected to give a dividend of Rs. 1 per share in 12 days.

An investor holding the underlying share will receive the dividend. But the holder of Reliance Futures will not be entitled to the dividend. The Present Value of Dividend (PVD) therefore will need to be subtracted from the spot price.

PVD = Rs. 1 ÷ $(1 + 6\%)^{(12/365)}$

= Rs. 0.998

FP = (S_0– PVD) X $(1+r)^t$

= (851.30 – 0.998) X $(1+6\%)^{(20\div 365)}$

= Rs. 853.05 (rounded to multiple of 0.05)

This calculated price is the "no arbitrage" price, where the investor is neutral between buying in the cash market and futures market. If Reliance Futures are available in the market at a price lower than the "no arbitrage" price, then the investor would prefer to take the position with Reliance Futures instead of the underlying Reliance shares.

2.12 Determining Index Futures Price (without Dividend)

The logic is similar to that of stock futures. However, continuous compounding is normally used instead of discrete compounding. The formula thus translates to

$FP = S_0 \text{ X } e^{rt}$

Suppose Nifty spot is at 5945.7 on March 8. Cost of carry on continuous basis is 6.86% p.a. The price for March 28 Nifty Futures can be calculated as:

$FP = 5945.70 \text{ X } 2.71828^{(6.86\% \text{ X } 20 \div 365)}$

= 5968.10 (rounded to nearest 0.05)

As with Reliance Futures, this calculated price is the "no arbitrage" price i.e. the investor is neutral between buying the Nifty basket of stocks in the cash market as compared to Nifty Futures. If Nifty Futures is trading higher, then arbitragers will see opportunity for arbitrage. They will buy Nifty basket in spot and sell Nifty futures. This will raise the Nifty spot or pull down Nifty futures, thus restoring equilibrium.

2.13 Determining Index Futures Price (with Dividend)

As in the case of stock futures, the PVD will need to be adjusted. Since various companies will pay a dividend at different points of time, the calculation assumes dividend is paid continuously (not on discrete basis). This dividend rate is directly subtracted from the cost of carry, as shown below:

$FP = S_0 \text{ X } e^{(r-\delta)t}$

In the previous example, suppose the continuous dividend yield is 0.8%. The no-arbitrage futures price will be calculated as follows:

$FP = 5{,}945.70 \text{ X } 2.71828^{((6.86\%-0.8\%) \text{ X } 20 \div 365)}$

= 5,965.50 (rounded to nearest 0.05)

It may be noted that the calculations so far have been done per share or per unit of index. The actual contract value is determined by multiplying with the market lot (also called "contract multiplier").

For example, the market lot for Nifty Futures is 50. Therefore, the contract value would be Rs. 5,965.50 X 50 i.e. Rs. 298,275.

2.14 Cash & Carry Arbitrage

The examples so far considered a trader who wanted to take a position in Reliance or Nifty. The role of arbitrager in restoring equilibrium was also discussed. Let us now examine the role of arbitrager in detail.

Arbitragers do not want to take an exposure, but wish to earn riskless profits.

Suppose, in the earlier case, Reliance Futures with expiry on March 28, 2013 were available in the market at Rs. 854.70 (i.e. above equilibrium price). The investor would do the following trades:

March 8:

Buy Reliance Shares in the Cash Market @ Rs. 851.30

Sell Reliance Futures @ Rs. 854.70

Since the same underlying is being bought and sold, there is no change in net exposure. It is an arbitrage transaction.

March 28:

Sell Reliance Shares in the Cash Market @ say, Rs. 900

Buy Reliance Futures @ Rs. 900 (futures price will converge to spot on maturity)

Pay interest cost of Rs. 851.30 X 6% X (20÷ 365) i.e. Rs. 2.80

Arbitrage Profits:

Reliance Shares (Rs. 900 – Rs. 851.30)	Rs. 48.70
Reliance Futures (Rs. 854.70 – Rs. 900)	– Rs. 45.30
Net Margin on trades	Rs. 3.40
Less Interest Cost	Rs. 2.80
Arbitrage Profit	**Rs. 0.60**

The cash and carry arbitrage thus yields a riskless profit of Rs. 0.60. The profit does not depend on the price of Reliance shares on March 28. If the shares were trading at a price higher than Rs. 900, then the arbitrager would book higher profit on the shares, but also book a correspondingly higher loss on the futures position. The net arbitrage profit would remain the same. This is the essence of arbitrage – future change in price of the underlying does not affect the net profit or loss.

A point to note is that in these calculations, the margin payments on Reliance futures have not been considered. Profitability will be lower to the extent of interest cost on the margin payments. Similarly, brokerage and securities transaction tax will reduce the profits.

2.15 Reverse Cash & Carry Arbitrage

Suppose, in the above case, Reliance Futures with expiry on March 28, 2013 were available in the market at Rs. 853.70 (i.e. below equilibrium price). The investor would do the following trades:

March 8:

Sell Reliance Shares in the Cash Market @ Rs. 851.30

Invest the sale proceeds at 6%

Buy Reliance Futures @ Rs. 853.70

Since the same underlying is being bought and sold, there is no change in net exposure. It is an arbitrage transaction.

March 28:

Buy Reliance Shares in the Cash Market @ say, Rs. 900

Pay for the purchased shares by redeeming the earlier sale proceeds that were invested at 6%.

Receive interest income of Rs. 851.30 X 6% X (20÷ 365) i.e. Rs. 2.80

Sell Reliance Futures @ Rs. 900 (futures price will converge to spot)

Arbitrage Profits:

Reliance Shares (Rs. 851.30 – Rs. 900)	– Rs. 48.70
Reliance Futures (Rs. 900 – 853.70)	Rs. 46.30
Net Margin on trades	– Rs. 2.40
Add Interest Income	Rs. 2.80
Arbitrage Profit	**Rs. 0.40**

2.16 Convergence of Spot & Futures

The difference between futures price and spot price is called “basis”. Closer to maturity of the contract, the basis will trend towards zero.

On maturity of the futures contract, t is equal to 0. Substituting this value of ‘t’ in the formula for calculation of value of futures, it can be found that the futures price will equal the spot price on maturity.

Figure 2.1 is a pictorial representation of the convergence of futures price to spot price, taking a constant spot value of Nifty as 5,945.70 and continuously compounded cost of carry at 6.86%.

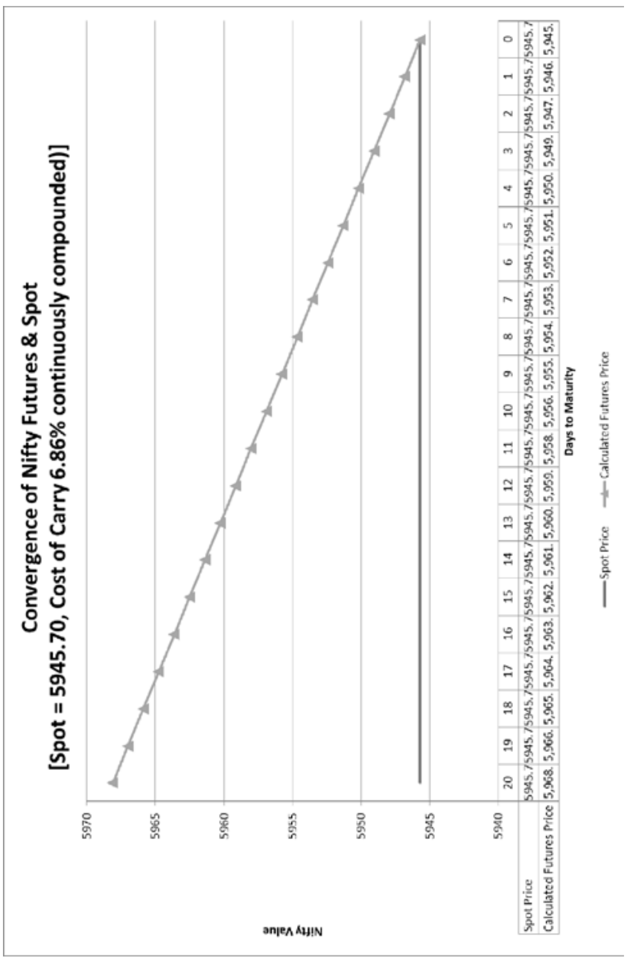
The graph depicts the convergence along a straight line. However, in reality, the prices of futures contracts in the market do vary from their "no-arbitrage" values. Therefore, the convergence happens in waves, rather than along a straight line.

2.17 Contango & Backwardation

On account of the cost of carry, futures price is higher than the spot price of the same underlying i.e. basis is positive. Such a relative price position is called *contango.* This is the normal position for equity futures that do not involve a dividend.

At times, on account of extremely bearish market situations or any technical factors, the futures price may be trading lower than the spot price of the same underlying. In such situations, the stock is said to be in *backwardation.* This is more common with commodity futures rather than financial futures, on account of some unique aspects driving valuation of commodity futures, as discussed below.

Figure 2.1



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[1] The examples used in the Workbook are for illustration only and are not a recommendation to buy or sell a security.

2.18 Cost of Carry – Commodities

Cost of carry was discussed earlier as an interest cost for carrying an investment position in equity shares or an equity index. The position yielded a return in the form of dividend (besides capital gain). Adjustment for dividend while valuing equity futures has already been discussed.

Investment in commodities like gold and oil entail another element of cost viz. storage cost. Further, commodities do not yield a dividend. However, the person holding the commodity may earn something out of it. This yield arising out of the convenience of holding the asset is called "convenience yield". These elements are part of the calculation of price of commodity futures, as follows-

Discrete basis:

$F = S_0 + PV\ (SC) - PV\ (CY)$

Where,

F is the theoretical price of a commodity future

S_0 is the spot price of the underlying commodity

PV (SC) is the present value of storage costs over the duration of the contract

PV (CY) is the present value of the convenience yield over the duration of the contract.

Continuously Compounded basis:

$F = S_0 \text{ X } e^{(r\text{-}sc+cy)t}$

Where,

F is the theoretical price of a commodity future

S_0 is the spot price of the underlying commodity

r is the risk-free rate / cost of carry

SC is the storage costs (% to asset value)

CY is the convenience yield (% to asset value)

t is the time period of the contract in years.

Self-Assessment Questions

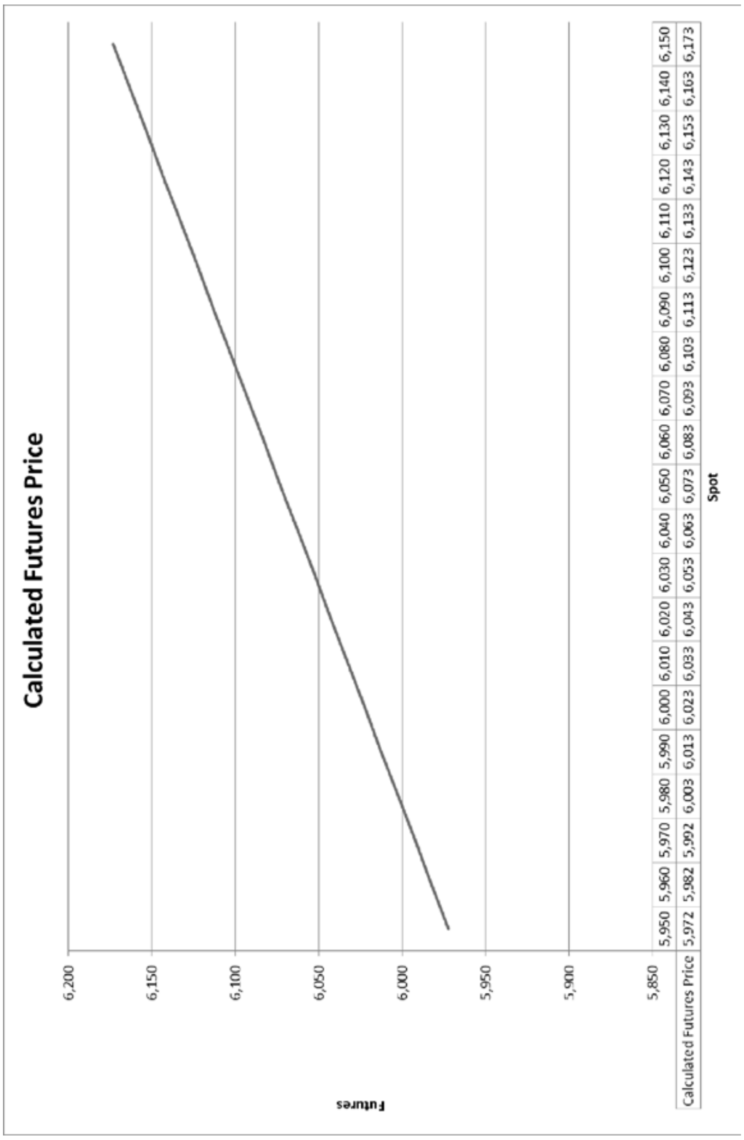
- Which of the following descriptors is used for stock futures?
  - STKFUT
  - **FUTSTK**
  - FSTK
  - SKFUT
- Futures contracts have to be of minimum value of __________
  - Rs. 1 lakh
  - Rs. 5 lakh
  - **Rs. 2 lakh**
  - Rs. 3 lakh
- Exposure margin on index futures is ___ of notional value of contract
  - 1%
  - 2%
  - **3%**
  - 5%
- Which of the following is cash and carry arbitrage?
  - Buy spot
  - Sell futures
  - **Both the above**
  - Sell spot and buy fures
- Stock X is quoting at Rs. 1000.55 in the cash market on April 2. Futures on Stock X, expiring on April 25 are trading at 1004.65. An investor is in a position to borrow or lend unlimited amounts at 6% (discrete). What trade should he do and how much will he earn in the process, if Stock X goes down to Rs. 800 on April 25? [Please do the calculations on per share basis]
  - **Cash & carry arbitrage, Rs. 0.32**
  - Reverse Cash & carry arbitrage, Rs. 0.32
  - No transaction, zero
  - Cash & carry arbitrage, Rs. 4.10

Chapter 3 Investment with Equity Futures

3.1 Relation between Futures and Spot Price

As the spot price goes up, the price of futures contracts on the same underlying will go up. This direct relationship between spot and futures contracts is depicted in Figure 3.1.

Figure 3.1



The graph depicts the relationship along a straight line. However, in reality, the prices of futures contracts in the market do vary from their "no-arbitrage" theoretical values. Therefore, the relationship is generally not so straight.

Even if not straight, the relationship is clearly direct. Therefore, investors have a choice of taking their investment position through spot market or futures markets, as discussed in the previous chapter.

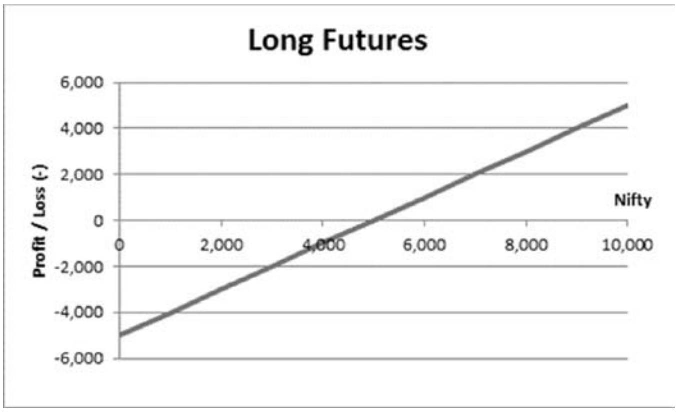
3.2 Payoff Matrix from Futures

3.2.1 Long Futures

The buyer of a futures contract is said to be long on futures. When the underlying grows in value, the futures contract gains in value too. Thus, the buyer benefits with a rise in the underlying. But, if the underlying were to lose value, then the futures contract will lose value too.

The relationship can be seen in payoff matrix shown in Figure 3.2. Here, an investor is presumed to have bought Nifty futures when the Nifty was at 5,000.

Figure 3.2

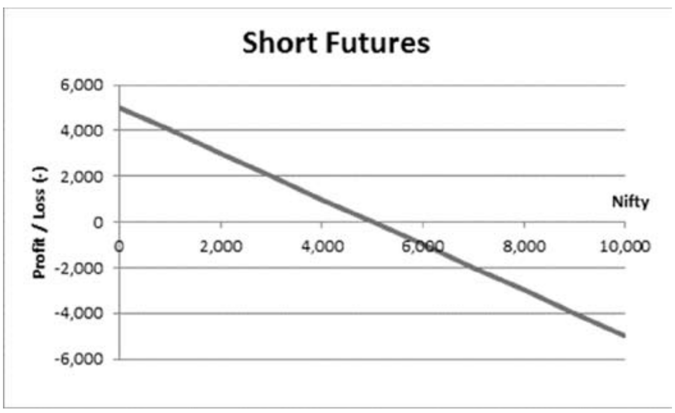


3.2.2 Short Futures

The seller of a futures contract is said to be short on futures. When the underlying grows in value, the futures contract gains in value too. But since the seller has short-sold the contract, he will lose money when he covers his position at a higher price. On the other hand, if the underlying were to lose value, then the futures contract will lose value too; the investor who shorted the Nifty future can now buy it back at a lower price and book a profit.

The relationship can be seen in the payoff matrix shown in Figure 3.3. Here, an investor is presumed to have sold Nifty futures when the Nifty was at 5,000.

Figure 3.3



3.3 Hedging with Futures

Suppose an investor has bought 5,000 shares of Infosys at Rs.2,800. This is a company he is bullish about. He is however concerned that if the general market goes down, then this stock too will lose value. He can hedge himself against a general decline in the market, by selling Nifty futures.

How many Nifty futures to sell, depends on the relationship between Nifty and the Infosys stock, which is captured by the beta of the stock (as discussed in Chapter 1). Suppose the beta of Infosys is 0.60.

The investor's position in Infosys is worth 5,000 X Rs. 2,800 i.e. Rs. 140 lakh.

The value of Nifty Futures to sell would be Rs. 140 lakh X 0.60 i.e. Rs. 84 lakh.

If the Nifty is at 6,000, and the contract multiplier for Nifty Futures is 50. The notional value of each Nifty Futures contract is 6,000 X 50 i.e. Rs. 3 lakh.

Thus, the investor will have to sell Rs. 84 lakh ÷ Rs. 3 lakh i.e. 28 Nifty Futures contracts to hedge against the purchase of 5,000 Infosys shares at Rs. 2,800.

Selling Nifty Futures to hedge against purchase of Infosys shares is not a perfect hedge (selling Infosys Stock Futures would be more perfect). How much of the risk is eliminated by selling Nifty futures? The answer lies in the R-square value. If the R-square value is 80%, then that means 80% of Infosys share returns is linked to Nifty returns. Thus, 20% of the fluctuations in Infosys share prices is on account of extraneous factors that are not hedged by selling Nifty Futures.

The beta value of 0.6 is called "hedge ratio"; the R-square value of 80% is called "hedge effectiveness".

3.4 Basis Risk

In the earlier example on Infosys, suppose Nifty moved up 10% to 6,600. The revised contract value would be 6,600 X 50 i.e. Rs. 3.3 lakh.

Based on its beta, one would expect Infosys to go up by 0.6 of 10% i.e. 6%. This would translate to a share price of Rs. 2,800 X 1.06 i.e. Rs. 2,968.

The gain on Infosys shares purchased would have been:

(Rs. 2,968 – Rs. 2,800) X 5,000 shares

i.e. Rs. 8.40 lakhs

The loss on Nifty futures sold would have been

(Rs. 3.3 lakh – Rs. 3 lakh) X 28 contracts

i.e. Rs. 8.40 lakhs

Thus, the gain in Infosys shares will be offset by the loss in Nifty futures, so long as Infosys share price changes in line with Beta. In reality, it may not change to the same extent, because the R-square value is less than 100%. Thus, despite the hedge, some risk remains. This risk which remains is called "basis risk". It arises because Nifty is not a perfect hedge for shares of Infosys.

Infosys Futures are a perfect hedge for Infosys shares. A plot of the two prices would give R-square value close to 100%. To illustrate the point, the data in Figure 3.1 has been extended to capture the relationship between returns on the spot and futures contracts (Figure 3.2).

The relationship between the two returns is captured by the equation

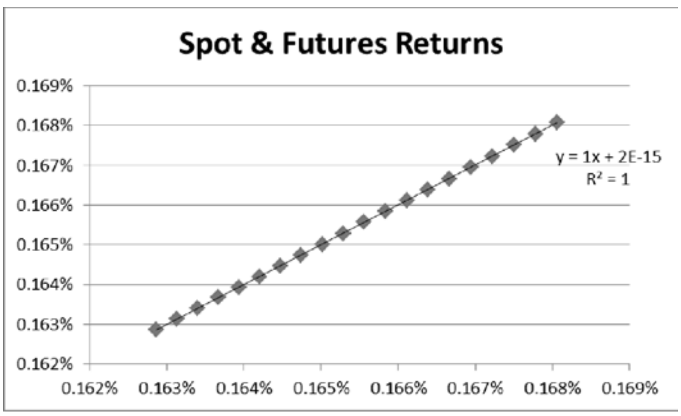
Y = 1X + (2E – 15)

Where, Y stands for returns in the Futures contracts and X stands for returns based on the Spot prices. (2E – 15) in the equation is a negligible value.

1X means that the slope (Beta) is 1.

R-square is 1 i.e. 100%.

Figure 3.4



There are several reasons why a hedger may opt for an imperfect hedge. For example:

- A contract offering a perfect hedge may not be available
- The contract offering a perfect hedge may be less liquid
- The contract offering a perfect hedge may not be available for the desired maturity
- The contract offering a perfect hedge may be costlier to transact

When the asset used for hedging is different from the asset being hedged, it is called "cross-hedging". For example, an automobile manufacturer may choose to hedge itself against fall in demand for its vehicles arising out of rising petrol prices, by buying oil futures. Thus, when the company's profits are hit by falling vehicle sales caused by rising oil prices, it will earn a profit in the oil futures.

3.5 Modifying the Portfolio Beta with Futures

Futures are useful for portfolio managers to modify the beta of their portfolio. In the Infosys example, the shares of Infosys had a beta of 0.6. If the portfolio had only this one share, the beta of the portfolio would have been 0.6. By selling the requisite Nifty futures, the portfolio manager has ensured that changes in Nifty do not affect the portfolio i.e. he had brought the portfolio Beta to 0.

Suppose he wanted to bring the portfolio beta to 0.45 instead of 0. Selling 28 Nifty Futures contracts brought down the portfolio beta from 0.6 to 0. In order to bring down the portfolio beta to 0.45, he needs to sell only 25% of the 28 Nifty Futures contracts i.e. 7 Nifty Futures contracts. In this manner, portfolio managers can target a beta for their portfolio, without changing the securities they have invested in.

3.6 Rolling Hedges

The underlying exposure may relate to a longer period than the hedge instruments available in the market. Suppose, the exposure is for a year, while the longest hedge instrument available in the market is of 3 months. The hedger has no option but to hedge for 3 months. At the end of 3 months, he will roll-over the hedge i.e. close the futures contract of the first quarter, and get into a new futures contract that will mature at the end of the second quarter. The same process will be repeated at the end of each quarter. This approach is called "rolling the hedge".

3.7 Investment Strategies Using Futures

Various investment strategies revolving around futures have been discussed:

- In this Chapter
    - Going long with futures
    - Going short with futures
    - Hedging with futures
    - Modifying portfolio beta
- Previous Chapter
    - Cash and carry arbitrage
    - Reverse cash and carry arbitrage

Derivatives can pose unique challenges in terms of margin payments and periodic booking of profits or losses, especially in the case of rolling hedges. Before getting into a position, it is essential for the top management to understand the cash flow impact and profit impact of the hedge, in various price scenarios.

Self-Assessment Questions

- The relationship between spot price and futures on the same underlying is
  - **Direct**
  - Indirect
  - Not strong
  - Direct or indirect depending on interest rates
- Which of the following is likely to earn profits if price of underlying goes up?
  - Long in cash market
  - Long in futures market
  - **Both the above**
  - Short in cash market and futures market
- An investor has bought a stock worth Rs. 15lakh. Its beta is 0.7, while R-square is 0.9. How will he hedge his position?
  - **Sell Nifty futures worth Rs. 10.5 lakh**
  - Buy Nifty futures worth Rs. 10.5 lakh
  - Sell Nifty futures worth Rs. 13.5 lakh
  - Sell Nifty futures worth Rs. 15 lakh
- Entering into fresh contracts on maturity of each contract is an example of
  - **Rolling hedge**
  - Cash and carry arbitrage
  - Reverse cash and carry arbitrage
  - Basis risk
- Basis risk is a consequence of imperfect hedge
  - **True**
  - False

Chapter 4 Interest Rate Futures

Just as risks in the equity market can be varied or hedged through equity futures, interest risk in the debt market can be varied or hedged through interest rate futures. Interest rate options are not permitted in India yet.

4.1 Interest Risk Management through Futures

The prices of fixed interest rate debt securities and yields in the market are inversely related. As market yields go up, market value of fixed interest rate debt securities already issued, go down, and vice versa.

We know that an investor can protect himself from a decline in equity prices by selling equity futures; he can benefit from an increase in equity prices by buying equity futures.

Similarly, an investor can protect himself from an expected decline in debt security prices (i.e. increase in market yields) by selling interest rate futures; he can benefit from an expected increase in debt security prices (i.e. decrease in market yields) by buying interest rate futures.

4.2 Contracts & Eligible Securities

Several debt securities are available in the market. Offering futures on each individual debt security is not practical, because the contracts would not have any liquidity in the market. In any case, yields in the market are the prime influence of security prices. Therefore, interest rate futures are offered only on a few real or notional debt securities.

For instance, in India, interest rate futures are available with underlying in the short term (91-day T-Bill) and long term (10-year Notional Government of India (GoI) security bearing coupon of 7%). These are traded in the Currency Derivatives segment on NSE's automated trading systems, NEAT plus and NOW (NEAT on Web). Trading hours are 9 am to 5 pm from Monday to Friday.

The trades are settled through India's only 'AAA' rated clearing corporation, the National Securities Clearing Corporation Limited (NSCCL), which acts as a central counterparty to all trades, and guarantees financial settlement.

While the short term interest rate futures (Contract descripter is FUTIRT) are cash settled, the long term interest rate futures (Contract descripter is FUTIRD) are settled through delivery of securities. The underlying for long term interest rate future viz 10-year Notional Government of India security bearing coupon of 7%, being notional, is not available for delivery. Therefore, NSE specifies a list of securities that are eligible for delivery. This list is prepared based on the following criteria:

- The GoI securities should be maturing at least 8 years but not more than 10.5 years from the first day of the delivery month.
- The GoI security should have minimum total outstanding stock of Rs. 10,000 crore.

4.3 Conversion Factor

Since each eligible security may be trading in the market at different yields and prices, NSE also announces a conversion factor for each eligible security for each contract. The conversion factor is equal to the price of the deliverable security (per rupee of principal) on the first calendar day of the delivery month, to yield 7% with semi-annual compounding.

As an illustration, a list of eligible securities and their conversion factor for two different series of contracts are given in Tables 4.1 and 4.2.

Table 4.1

Deliverable basket and conversion factor for Sept 2012 contract

Sr. No.	ISIN	Nomenclature	Date of maturity	Conversion Factor
1	IN0020110022	7.80% 2021	11-Apr-2021	1.0506
2	IN0020060318	7.94%2021	24-May-2021	1.0595
3	IN0020010040	10.25% 2021	30-May-2021	1.2056
4	IN0020110030	8.79% 2021	8-Nov-2021	1.1180
5	IN0020060037	8.20 % 2022	15-Feb-2022	1.0805
6	IN0020020072	8.35% 2022	14-May-2022	1.0925
7	IN0020070028	8.08% 2022	2-Aug-2022	1.0752
8	IN0020039031	5.87%2022 (conv)	28-Aug-2022	0.9210
9	IN0020070051	8.13% 2022	21-Sep-2022	1.0803
10	IN0020120013	8.15% 2022	11-Jun-2022	1.0801

Source: www.nseindia.com

Table 4.2

Deliverable basket and conversion factor for Dec 2012 contract

Sr. No.	ISIN	Nomenclature	Date of maturity	Conversion Factor
1	IN0020110022	7.80% 2021	11-Apr-2021	1.0493
2	IN0020060318	7.94%2021	24-May-2021	1.0580
3	IN0020010040	10.25% 2021	30-May-2021	1.2009
4	IN0020110030	8.79% 2021	8-Nov-2021	1.1155
5	IN0020060037	8.20 % 2022	15-Feb-2022	1.0791
6	IN0020020072	8.35% 2022	14-May-2022	1.0906
7	IN0020070028	8.08% 2022	2-Aug-2022	1.0740
8	IN0020039031	5.87%2022 (conv)	28-Aug-2022	0.9225
9	IN0020070051	8.13% 2022	21-Sep-2022	1.0787
10	IN0020120013	8.15% 2022	11-Jun-2022	1.0788
11	IN0020030014	6.30% 2023	9-Apr-2023	0.9493

Source: www.nseindia.com

4.4 Cheapest to Deliver (CTD)

Various GoI securities are eligible for delivery in interest rate futures, as already seen. Out of these, the bond which can be bought at the cheapest price from the underlying bond market and delivered against an expiring futures contract is called CTD bond.

When a party purchases a bond in the market, it has to pay the "dirty price", which is the summation of quoted price (called "clean price") and accrued interest (for the period from the last interest payment date on the bond to the date the trade is being settled between buyer and seller of the bond).

For example, suppose a bond has interest payment dates on June 30 and December 31. A party purchasing the bond on July 15 will pay the clean price and accrued interest for the period July 1 to July 15. This is compensation for the seller for having held the bonds for the period since the last interest payment date.

(The issuer will pay the interest to the holder of the bonds on the interest payment date. If the buyer holds the bond long enough, it will receive the interest for the entire 6 month period from July 1 to December 31, though it purchased the bonds only on July 15).

Accrued interest is calculated using 30/360 day count convention which assumes each month has a period of 30 days; the year has 360 days.

Thus, the cost of purchasing a bond for delivery is:

Quoted Price of Bond + Accrued Interest

The party with the short position in interest rate futures will receive:

(Futures Settlement Price X Conversion Factor) + Accrued Interest

CTD is the bond where difference between the two is most beneficial to the seller i.e.the bond where

Quoted price of Bond – (Futures Settlement Price * Conversion Factor)

is the lowest. The concept is illustrated in Table 4.3.

Table 4.3

Cheapest to Deliver Bond

Security	Futures Settlement Price *	Quoted Price of Bond * (A)	Conversion Factor (CF)	Futures Settlement Price X CF (B)	Difference (A – B)
7.46 2017	100	102.74	1.0270	102.70	0.04
6.05 2019	100	95.64	0.9360	93.60	2.04
6.35 2020	100	96.09	0.9529	95.29	0.80
7.94 2021	100	104.63	1.0734	107.34	-2.71
8.35 2022	100	107.02	1.1113	111.13	-4.11
6.30 2023	**100**	**89.75**	**0.9395**	**93.95**	**-4.20**

* Assumed

The last mentioned bond is the CTD.

4.5 Contract Structure &Mechanics of FUTIRD

- Notional Value

Each FUTIRD represents notional bonds of face value Rs. 2 lakh.

Quantity freeze limit is 1,250 units i.e. trades upto this size can go through in the trading system without the intervention of the exchange.

- Expiry of Contracts

Two fixed quarterly contracts for entire year ending March, June, September and December. Thus, in April 2013, contracts are available for expiry in June 2013 and September 2013.

The last trading day for a contract is 2 business days prior to settlement delivery date. That is also the last day for sellers to intimate their intention regarding delivery of the underlying (by 6 pm).

The delivery day is the last business day of the contract expiry month.

- Margins & Settlement

In any derivative contract, the clearing house protects itself from client default by recovering initial margin and daily marked to market (MTM) margins.

Initial margin is based on SPAN (Standard Portfolio Analysis of Risk). The minimum initial margin for 10-Year Notional Coupon bearing GOI security futures contract is 2.33% on the first day of Interest Rate Futures trading and 1.6 % thereafter.

Daily MTM margin is calculated based on daily settlement price. It is to be settled in cash on T+1 basis.

Once the positions are intended for delivery and allocation has been done, the following margins are levied

- Margin equal to VaR on the futures contract on the invoice price plus 5% on the face value of the security to be delivered
- Mark to market loss based on the underlying closing price of the security intended for delivery.

These are levied on both buyer and seller.

In cases where the positions are open at end of last trading day and no intention to deliver has been received, the following margins are levied.

- Margin equal to VaR on the futures contract on the invoice price of the costliest to deliver security from the deliverable basket plus 5% on the face value of the open positions
- Mark to market loss based on the underlying closing price of the costliest to deliver security from the deliverable basket.

These are levied on both buyer and seller.

Final settlement on expiry of contracts is through physical delivery of securities, as per conversion factor already discussed.

4.6 Contract Structure & Mechanics of FUTIRT

- Notional Value

Each FUTIRT denotes 2000 units of the underlying 91-day T-Bills. Since each T-Bill has a face value of Rs. 100, the contract has a notional value of 2000 X Rs. 100 i.e. Rs. 2 lakh.

Quantity freeze limit is 7,000 units.

- Expiry of Contracts

FUTIRT contracts are permitted for every month for the first 3 months, and thereafter every quarter for 3 quarters. They expire at 1 pm on the last Wednesday of the concerned month. In case the last Wednesday of the month is a designated holiday, the expiry day would be the previous working day.

Thus, in April 2013, the permitted contracts are those expiring on April 24, 2013; May 29, 2013; June 26, 2013; September 25, 2013; December 25, 2013; and March 26, 2014.

While the futures contract would expire on a Wednesday, it is for an underlying 91-day T-Bill which will mature 91 days after the expiry of the futures contract.

Suppose the settlement date is April 11, 2013. The near month futures contract will expire on April 24, 2013. But the underlying is a T-Bill that will mature 91 days later, on July 24, 2013.

The period of 13 days from April 11, 2013 to April 24, 2013 is the "balance tenor" of the futures contract

After the expiry day of the futures contract, the underlying 91-day T-Bill (which is to mature on July 24, 2013) will have a "forward period" of 90 days.

The summation of the two periods, 13 + 90 i.e. 103 days is the "residual tenor" of the exposure.

- Pricing terminology

Prices are quoted in the market at (100 – Futures Discount Yield). For example, if the discount yield is 4%, the quote price would be Rs. 100 – Rs. 4 i.e. Rs. 96. This is the *quote price.*

The futures discount yield of 4% translates to 4% X 0.25 i.e. 1% for 91 days (which is the duration of the underlying T-Bill). The T-Bill will be valued in the money market at Rs. 100 – Rs. 1 i.e. Rs. 99. This is the *valuation price.*

At this price, the contract value translates to 2,000 units X Rs. 99 i.e. Rs. 198,000.

Money market yield is (Rs. 1 ÷ Rs. 99) X (365 ÷ 91) i.e. 4.05%

Discount yield is (Rs. 1 ÷ Rs. 100) X (360 ÷ 90) i.e. 4%

The user has to input any one of the following in the trading screen:

- o Quote price (Rs. 96)
- o Valuation price (Rs. 99)
- o Money market yield (4.05%).

- Margins & Settlement

Initial margin is based on SPAN (Standard Portfolio Analysis of Risk). It is subject to minimum of 0.1 % of the notional value of the contract on the first day and 0.05 % of the notional value of the contract thereafter.

For the daily MTM margin, settlement price is calculated every day, as Rs. 100 – 0.25 X Weighted Average Futures Yield. The weighted average is calculated on the basis of:

- Trades in last half hour of trading, if at least 5 trades have been executed.
- Else, trades in last 1 hour of trading, if at least 5 trades have been executed.
- Else, trades in last 2 hours of trading, if at least 5 trades have been executed.

In the absence of adequate trades, theoretical futures yield is derived using T-Bill benchmark rates as published by Fixed Income Money Market and Derivatives Association of India (FIMMDA).

- Yields are first intrapolated / extrapolated for balance tenor of the contract and residual tenor of the exposure.
- Based on this, yield for the forward period of 90 days is computed.

Suppose futures contract was executed at valuation price of Rs. 99. Subsequently, the daily MTM settlement price came to Rs. 99.25. The buyer of the futures contract has made a MTM profit of Rs. 0.25 per unit. Since each contract represents 2,000 units, the MTM profit on the contract would be 2,000 X Rs. 0.25 i.e. Rs. 500.

Final settlement is done one day after expiry of the contract. The final settlement price is worked out on the basis of weighted average discount yield obtained from weekly 91 Day T-Bill auction of RBI. Suppose the yield was 4.2%. The final settlement price would be Rs. 100 – 0.25 X 4.2% i.e. Rs. 98.95.

Since yield has gone up, the final settlement price is lower than the original purchase price for the future. The buyer of the future has made a loss of (Rs. 99 – Rs. 98.95) i.e. Rs. 0.05 per unit. On the contract of 2,000 units, the loss would be 2,000 X Rs. 0.05 i.e. Rs. 100.

All T-Bill futures are cash settled in this manner.

Self-Assessment Questions

- For a GOI security to be eligible for delivery in interest rate futures contracts, it should have a minimum outstanding stock of
  - Rs. 1,000 cr
  - Rs. 5,000 cr
  - **Rs. 10,000 cr**
  - Rs. 25,000 cr
- Interest rate futures on T-bills in India are cash settled
  - **True**
  - False
- The party with short position in interest rate futures will receive, on final settlement
  - Futures settlement price
  - Futures settlement price X conversion factor
  - **(Futures settlement price X conversion factor) + Accrued Interest**
  - Market price of security delivered
- What is the notional value of bonds underlying FUTIRD contract?
  - Rs. 50,000
  - Rs. 1 lakh
  - **Rs. 2 lakh**
  - Rs. 5 lakh
- Each FUTIRT contract represents ______ 91-day T-Bills
  - 10,000
  - 5,000
  - **2,000**
  - 1,000

Chapter 5 Black-Scholes Option Pricing Model

5.1 European Call Option

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

$C = S_0 N(d_1) - Ke^{-rT}N(d_2)$

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

<u>Example 5.1</u>

Suppose a stock, trading at Rs. 20, has annual volatility of 15%. A 3-month option on that stock has exercise price of Rs. 17. Continuously compounded risk-free rate is 8% p.a. What would be its price as per Black Scholes model, 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

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

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

Ke^{-rt} = 17 X $2.71828^{-0.08 \times 0.25}$ 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 as per Black Scholes Option Pricing Model 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).

5.2 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 5.2

What is the value of European put for the same numbers as Example 5.1?

$N(-d_1)$ = 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).

5.3 Dividends

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

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

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

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

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

Example 5.3

What is the value of European Call and Put for the same numbers as Example 5.1, if the continuous dividend yield is 2%?

q = 2%

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

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

$e^{-qt} = 2.71828^{-0.02 \times 0.25}$ 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).

5.4 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.

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 6 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.

6.1 Delta

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

6.1.1 European Call on non-dividend paying stock

Δ of call = $N(d_1)$

Where,

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

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.

<u>Example 6.1</u>

Let us consider the same option that was discussed in Example 5.1 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 6.1. 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 6.1

Relation between Stock Price and Delta

6.1.2 European Put on non-dividend paying stock

Δ of put = $N(d_1) - 1$

For Example 6.1, it can be calculated to be – 0.0067.

The secondary Y axis on the right of the graph in Figure 6.1 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.

6.1.3 European Call on asset paying a yield of q

Δ of call = $e^{-qT} N(d_1)$

In example 6.1, if we assume the continuous dividend on the stock at 2%, delta of the call can be computed to be 0.9883.

6.1.4 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

6.2 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 6.1, 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.

6.2.1 European Call / Put on non-dividend paying stock

$$\Gamma = \frac{N'(d_1)}{S_0 \sigma \sqrt{T}}$$

Where,

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

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

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

For example 6.1, the values can be substituted in the above formula to arrive at the Gamma value of 0.0126.

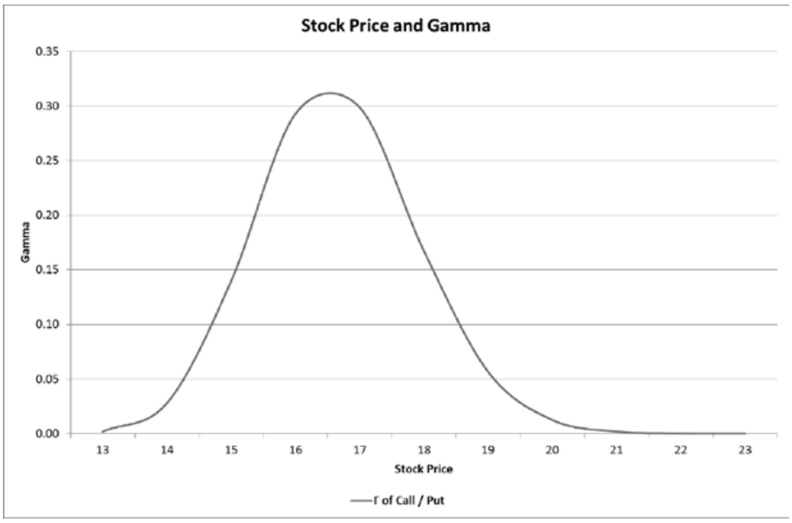
The movement in gamma of the option mentioned in Example 6.1, as the stock price changes can be seen in Figure 6.2.

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 6.2

Relation between Stock Price and Gamma



6.2.2 European Call / Put on asset paying a yield of q

$\Gamma = \dfrac{N'(d_1)e^{-qT}}{S_0 \sigma \sqrt{T}}$

For example 6.1, taking continuous dividend at 2%, the Gamma value can be calculated as 0.0125.

6.3 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).

6.3.1 European Call on non-dividend paying stock

$\Theta = -\dfrac{S_0 N'(d_1)\sigma}{2\sqrt{T}} - rKe^{-rT}N(d_2)$

Where,

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

Substituting the values from Example 6.1, 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.

6.3.2 European Put on non-dividend paying stock

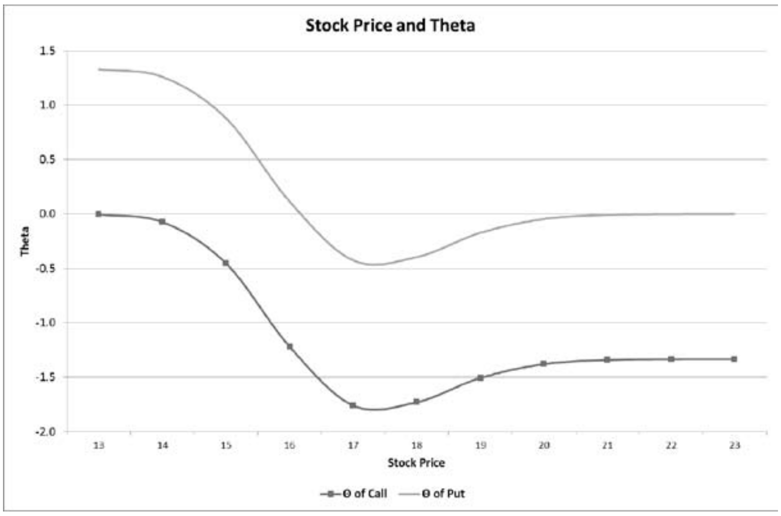
$$\Theta = -\frac{S_0 N'(d_1)\sigma}{2\sqrt{T}} + rKe^{-rT}N(-d_2)$$

Substituting the values from Example 8.1, 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 6.3.

Figure 6.3

Relation between Stock Price and Theta



6.3.3 European Call on asset paying yield of q

$$\Theta = \frac{S_0 N'(d_1)\sigma e^{-qT}}{2\sqrt{T}} + qS_0N(d_1)e^{-qT} - rKe^{-rT}N(d_2)$$

Taking compounded dividend at 2%, the theta in the case of Example 6.1 works out to – 0.9829.

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

6.3.4 European Put on asset paying yield of q

$$\Theta = \frac{S_0 N'(d_1)\sigma e^{-qT}}{2\sqrt{T}} - qS_0N(-d_1)e^{-qT} + rKe^{-rT}N(-d_2)$$

Taking compounded dividend at 2%, the theta in the case of Example 6.1 works out to – 0.0479.

6.4 Vega

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

6.4.1 European Call / Put on non-dividend paying stock

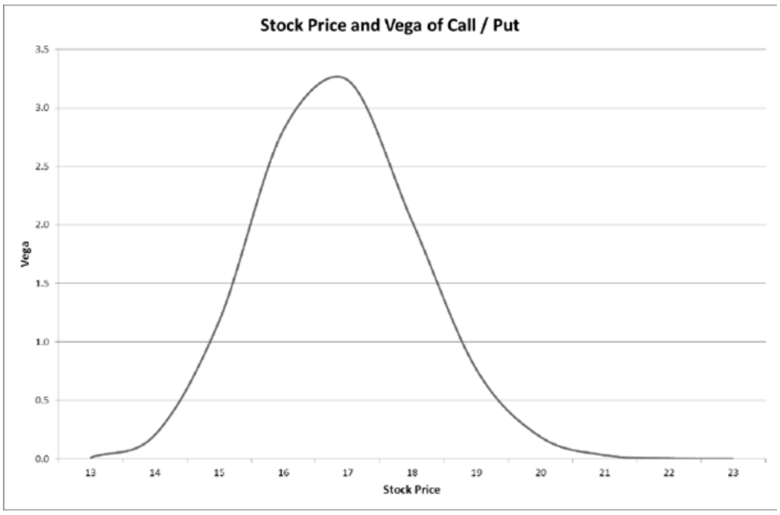
$\upsilon = S_0\sqrt{T}\, N'(d_1)$

In the case of Example 6.1, it works out to 0.1883.

The change in Vega for different values of the stock price for the option in Example 6.1 is shown in Figure 6.4

Figure 6.4

Relation between Stock Price & Vega



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

6.4.2 European Call / Put on asset paying yield of q

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

In Example 6.1, with continuous dividend of 2%, the calculated value is 0.1874.

6.5 Rho

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

6.5.1 European Call on non-dividend paying stock

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

In the case of Example 6.1, the calculated value is 4.1313.

6.5.2 European Put on non-dividend paying stock

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

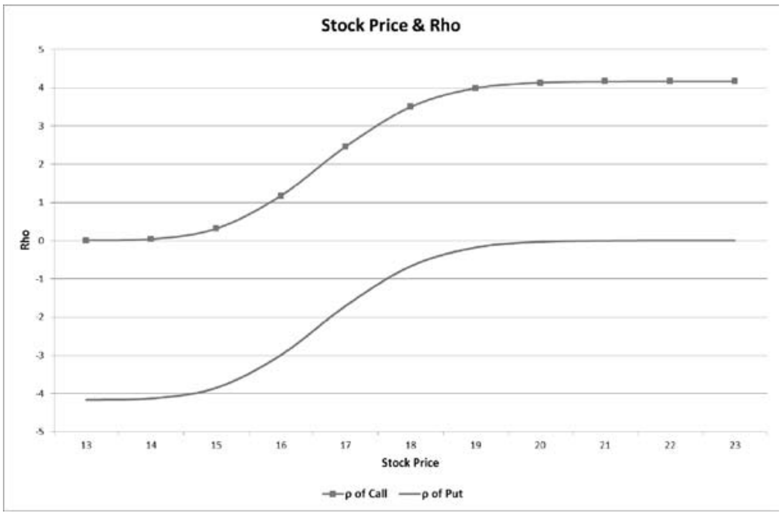
The calculated value is – 0.0345 for Example 6.1.

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

Figure 6.5 shows how Rho of call and put options changes with the stock price.

Figure 6.5

Relation of Stock Price and Rho



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 7 Currency Futures & Options

In a globalised world, the role of international investment and trade activities is increasing. Most international transactions entail an exposure to a foreign currency. Importers, exporters, lenders and investors may seek to cover the risks arising out of their foreign currency exposure. Speculaters wish to benefit from expected changes in the exchange rates.

As in the case of equity and debt, exposures to currency too can be taken directly or through futures and options.

7.1 Currency Futures Contracts

Currency future is a contract to exchange one currency for another at a specified date in the future at a price (exchange rate) that is fixed on the purchase date.

On NSE the price of a currency future contract is in terms of INR per unit of the other currency. Currency futures are available on four currency pairs viz. US Dollars (USD)-INR, Euro (EUR)-INR, Great Britain Pound (GBP)-INR and Japanese Yen (JPY)-INR. These are traded in the currency derivatives segment of NSE from Monday to Friday 9 am to 5 pm.

The descripter used for currency futures is "FUTCUR". The symbols used for the respective contracts are USDINR, EURINR, GBPINR and JPYINR.

Each contract represents 1,000 units of the relevant foreign currency, except JPYINR, which represents 100,000 Japanese Yen. Quantity freeze comes into effect if the order is for more than 10,000 contracts.

Contracts are traded on a 12 month trading cycle. They expire at 12 noon, two working days prior to the last business day of the expiry month.

Initial margin is based on SPAN. It is based on 99% value at risk over a two-day time horizon. Minimum margin is 1% for USDINR; 2% for EURINR and GBPINR; 2.3% for JPYINR.

Different calendar spread margins are prescribed in rupees for various currencies and contract periods.

Daily settlement price is based on weighted average price in last half hour of trading. Daily settlement is on T+1 basis.

Theoretical daily settlement price is computed for unexpired futures contracts, which are not traded during the last half an hour on a day.

The final settlement price is the RBI reference rate. Final settlement is on the last business day. It is settled on T+2 basis.

7.2 Calculation of Daily Settlement Price of Currency Futures

The theoretic daily settlement price is given by the following formula:

$F_0 = S_0 X\ e^{(r-rf)T}$

where:

F_0 = Theoretical futures price

S_0 = Value of the underlying

r = Cost of financing (using continuously compounded interest rate)

rf = Foreign interest rate (continuously compounded basis)

T = Time till expiration (in years)

e = 2.71828

Rate of interest (r) may be the relevant MIFOR (Mumbai Inter-Bank Forward Rate) or such other rate as may be specified by the Clearing Corporation from time to time.

Foreign risk free interest rate is the relevant LIBOR rate or such other rate as may be specified by the Clearing Corporation from time to time.

Suppose, spot USD is at Rs. 50 and 1-year interest rate is 8% in India and 3% in US (both on continuous compounded basis). The value of a 1-year future on the USD is calculated as:

S_0 X $e^{(r-rf)T}$

i.e. 50 X $2.71828^{(8\% - 3\%) \times 1}$

i.e. Rs. 52.5636

Each FUTCUR USDINR contract, which represents 1,000 USD will therefore be valued at Rs. 52.5636 X 1,000 i.e. Rs. 52,563.60.

Quantity freeze would be applicable beyond 10,000 such contracts.

7.3 Transactions in Currency Futures

Suppose X has USD1,000. He needs to convert it to INR in a year. He can do the conversion right away, or in a year.

- Using the same numbers as the previous example, if he does the conversion immediately, he will receive 1,000 X Rs. 50 i.e. Rs. 50,000.

  Investing the money at 8% continuously compounded basis, he will have Rs. 50,000 X $2.71828^{(8\% \times 1)}$ i.e. Rs. 54,164.35.

- Suppose X chooses to do the conversion in 1 year while hedging himself by selling 1-year currency futures.

The USD 1,000 will grow at 3% continuously compounded basis to USD 1,000 X $2.71828^{(3\% \times 1)}$ i.e. USD 1,030.455. At the futures exchange rate, it will amount to Rs. 1,030.455 X 52.5636 i.e. Rs. 54,164.40. This is the same as the immediate conversion option (minor difference being on account of rounding off).

Thus, the futures price calculated represents a no-arbitrage price. If futures were being traded in the market at an underlying exchange rate of Rs. 53 per USD, then X would prefer to use the futures. However, if futures were being traded at an underlying exchange rate of Rs. 52 per USD, then X would prefer immediate conversion of USD to INR.

Speculaters in the market ensure that futures prices remain closer to the no-arbitrage price.

7.4 Currency Futures or Forward Rate Agreement

In the earlier example, there are a few issues to understand:

- X would have had to sell currency futures worth USD 1,030.455. But since the contracts are available in multiples of USD 1,000, he will sell 1 contract, and retain an open position for the remaining USD 30.455.
- On the sale of currency futures, X would be subject to margin payments. Initial margin would need to be paid. Thereafter, depending on how the currency moves, he will keep receiving or paying daily MTM margins.
- The futures contracts are cash settled. Therefore, X will not be able to deliver the USD 1,000 in the stock exchange. He will sell it to his bank at the spot rate prevailing at the end of 1 year. While the futures contract will be cash settled at the RBI Reference Rate, the spot rate that the bank would give him after 1 year can be slightly different from the RBI Reference Rate.

Instead of currency futures, X can enter into a forward rate agreement with the bank to sell USD at the end of 1 year at a rate that is decided today. The benefit of this approach for X is:

- X can do the forward rate agreement for odd amounts. He is not constrained by the USD 1,000 contract unit.
- Margin payments are avoided.
- X is also not exposed to a potential gap between the RBI Reference Rate on maturity, and the spot rate that the bank would offer at that time.

However, the following disadvantages of forward rate agreements need to be understood:

- At the same point of time, various banks offer different exchange rates for the forward contract. There is a lack of transparency in offering these rates, because of which X can lose heavily on the forward exchange rate. Currency futures, on the other hand, are traded in the market, and the prices are transparently available through the net and other media.

- If the currency were to move in his favour, X can keep receiving margin payments on the currency futures he has sold. In a forward rate agreement however, X will get the benefit of this favourable movement in exchange rates only at the end of the forward period.

7.5 Currency Options Contracts

The descripter used for Currency Options is OPTCUR. In India, these are available only on USD-INR. Each contract unit represents 1,000 USD.

NSE offers European Calls and Puts on USD-INR. The premium is quoted in INR.

3 serial monthly contracts are available, followed by 1 quarterly contract of the cycle March/ June/September/December. Thus, in April 2013, contracts are available for expiry in April, May, June and September 2013.

The last trading day is two working days prior to the last business day of the expiry month, at 12 noon. Final settlement day is the last business day of the expiry month.

Strikes are available at intervals of Rs. 0.25. 12 in the money, 12 out of the money and 1 near the money option of each type (call / put) are available. Quantity freeze kicks in for orders above 10,000 units.

All in-the-money open long contracts are automatically exercised at the final settlement price and assigned on a random basis to the open short positions of the same strike and series.

Buyer has to pay the premium in cash on T+1.

Initial margin, payable by the seller, is SPAN-based.

Final settlement price is the RBI reference rate on the date of expiry of the contract. All contracts are cash settled in rupees.

7.6 Valuation of Currency Options

The Black Scholes formulae used for valuing stock options need to be modified to value currency options.

7.6.1 European Call Option

$C = S_0 e^{-r_f T} N(d_1) - K e^{-rT} N(d_2)$

Where,

C stands for Call option

S_0 is the current price of the foreign currency 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

rf is the continuously compounded risk-free foreign currency interest rate

r is the continuously compounded risk-free local currency interest rate

T is the time to maturity of the option (in years)

d_1 is defined to be $\frac{In(S_0 \div K) + (r - rf + \sigma^2 \div 2)T}{\sigma\sqrt{T}}$

d_2 is defined to be $\frac{In(S_0 \div K) + (r - rf - \sigma^2 \div 2)T}{\sigma\sqrt{T}}$ i.e. $d_1 - \sigma\sqrt{T}$

σ is the annual volatility of the exchange rate

Example 7.1

Suppose USD =Rs. 50. It has annual volatility of 15%. A 3-month option on USD has exercise price of Rs. 52. Continuously compounded risk-free rupee rate is 8% p.a; dollar rate is 3% p.a.. What would be its price as per Black Scholes model, if it is an European Call?

S_0= Rs. 50

K = Rs. 52

e = 2.71828

r = 8%

rf = 3%

T = 3 ÷ 12 i.e. 0.25

σ = 0.15

$d_1 = \frac{In(50 \div 52) + (0.08 - 0.03 + 0.15^2 \div 2)\times 0.25}{0.15\sqrt{0.25}}$ i.e. -0.31878

$d_2 = \frac{In(50 \div 52) + (0.08 - 0.03 - 0.15^2 \div 2)\times 0.25}{0.15\sqrt{0.25}}$ i.e. -0.39378

$e^{-rf\ T}$= $2.71828^{-3\%\ X\ 0.25}$ i.e. 0.992528

Ke^{-rt} = 52 X $2.71828^{-0.08\ X\ 0.25}$i.e.50.97033

$N(d_1)$ = NORM.S.DIST(-0.31878,TRUE) = 0.374948

$N(d_2)$ = NORM.S.DIST(-0.39378,TRUE) = 0.346873

The price of a Call is $S_0 e^{-r_f T} N(d_1) - Ke^{-rT} N(d_2)$

Substituting, we get (50 X 0.992528 X 0.374948)–(50.97033 X 0.346873)

i.e. Rs. 0.93

The price of the call as per Black Scholes Option Pricing Model is Rs. 0.93.

The total acquisition cost of a share on exercise of call would be Rs. 0.93 (call premium) + Rs. 52 (exercise price) i.e. Rs. 52.93.

Thus, from the current spot exchange rate of Rs. 50, if the USD strengthens to more than Rs. 52.93 in 3 months, the buyer of the call option will break even (ignoring interest cost on call premium paid).

7.6.2 European Put Option

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

$P = Ke^{-rT} N(-d_2) - S_0 e^{-r_f T} N(-d_1)$

<u>Example 7.2</u>

What is the value of European put for the same numbers as Example 7.1?

$N(-d_1)$ = NORM.S.DIST(0.31878,TRUE) = 0.625052

$N(-d_2)$ = NORM.S.DIST(0.39378,TRUE) = 0.653127

Substituting, we get (50.97033 X 0.653127)–(50 X 0.992528 X 0.625052)

i.e. Rs. 2.27.

[Students are advised to familiarise themselves with such calculations. Similar problems are included in the Examination]

7.7 Transactions in Currency Options

In the example given earlier, X was committed to an exchange rate, irrespective of whether he converted to INR immediately (at Rs 50), or whether he sold currency futures (at Rs. 52.5636). If the USD were to strengthen considerably, to say, Rs. 55 per USD, X cannot benefit from that movement.

Instead, suppose X had purchased a put option to sell USD in 1 year at Rs. 52.50. He would have had to pay an option premium for buying the put option contract (which would have given him the right to sell USD 1,000). However,

- If the USD were to strengthen to say, Rs. 55, X can choose to let the option lapse. The extra money that he will earn by selling the USD at a higher rate would more than make up for the premium paid.

- If the USD were to weaken to say, Rs. 48, the put option will appreciate in value. The extra money thus earned on the put option, can make up for the loss X would face in selling his USD 1,030.455 at a lower exchange rate of Rs. 48.

Similarly, a party Y that needs to make a payment of USD 1,000 after 1 year, can buy a 1-year call at a strike of Rs. 52.50. It will need to pay an option premium. However, the put will entitle Y to buy USD 1,000 in 1 year at Rs. 52.50.

- If the USD were to strengthen to say, Rs. 55, Y's call option will gain value. The gain on that will cover Y for the higher price at which it will buy the USD from its bank in the cash market.
- If the USD were to weaken to say, Rs. 48, Y can let the call option lapse. The benefit that it will have of buying USD at this low price will more than cover for the option premium paid.

As in the case of futures, options too are traded in the market. Thus, there is a transparency associated with the pricing of such trades.

Self-Assessment Questions

❖ In the NSE, currency futures contracts are defined in terms of

- **INR per unit of foreign currency**
- INR per unit of foreign currency only in the case of USD; else foreign currency per INR
- INR per unit of foreign currency only in the case of JPY; else foreign currency per INR
- Foreign currency per unit of INR

❖ Each currency futures contract on NSE represents __________ units of JPY

- 1,000
- 100
- 10,000
- **100,000**

❖ Final settlement price for USD currency futures in NSE is

- **RBI reference rate**
- Weighted average price in last half hour of trading
- Weighted average price in last hour of trading
- None of the above

❖ If GBP is at Rs. 80. On continuously compounded basis, Indian interest rate is at 9% and UK interest rates at 4%. What should be the price for a 6-month currency futures contract?

- Rs. 84.1017
- **Rs. 82.0252**
- Rs. 87.20
- Rs. 84

❖ Currency options are available on the NSE for

- **USD**
- GBP
- EUR
- All the above

Chapter 8 Swaps

Swaps are contracts where the two 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 or commodities.

8.1 OTC Products

Unlike futures and options, which are created and traded in the stock exchanges, swaps are "over-the-counter" (OTC) products. These are not traded in a stock exchange. Often a bank finds two parties with divergent views about the market (interest rates, exchange rates etc.) and facilitates swap trade/s between them. The bank performs either of two roles:

- Broker

  Here, the swap will be direct between the two parties. So the two parties will know each other when the bank brokers the swap. As broker, the bank will earn commission from one or both parties.

- Dealer

  Here, the bank executes independent swap trades with both parties. Consequently, neither party will know the identity of the other; for both parties, the bank is the counter-party.

  In such trades, the bank earns the difference between the two matching trades. Suppose the bank agrees to pay 7% fixed to one party (in return for MIBOR), and receive 5% fixed from the other party (in return for MIBOR). The bank neither has an exposure to MIBOR nor an exposure to fixed interest rate, on account of the combination of the two swaps. Yet, it will earn a spread of 2% p.a., calculated on the notional principal. The bank is however exposed to credit risk from both parties.

  Since swaps are OTC products, without the benefit of a transparent pricing benchmark, the spreads can be quite large. This is the reason parties explore exchange traded futures and options. The discussion in Chapter 7 on forward rate agreement v/s currency futures is equally applicable for such swaps v/s currency futures (or options).

8.2 Interest Rate Swap

This is the most elementary form of a swap.

Suppose Party A is worried about its 2-year loan of Rs. 1 crore, on which it has committed to pay interest at 1-month MIBOR + 2% (Mumbai Inter-Bank Offered Rate). If interest rates were to go up, it will have to pay higher interest to its lender.

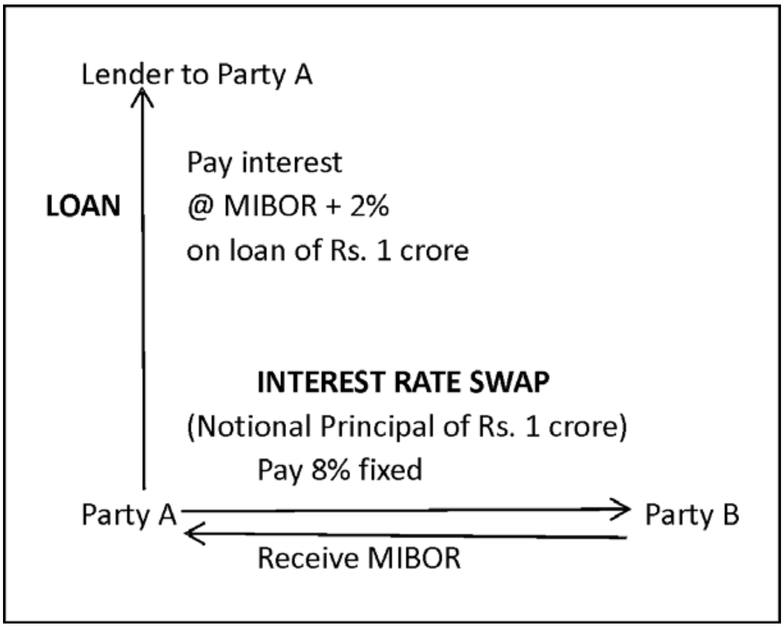
On the other hand, Party B is worried that interest rates may fall, and it will earn less on its deposits.

Party A and Party B can do an interest rate swap. Party A will agree to pay Party B interest at a fixed rate, say 8%, in return for a receipt of 1-month MIBOR, calculated on a notional principal of Rs. 1 crore.

While the swap may be direct between Party A and Party B, it is understood better if we bring in a 3rd party viz. Party A's Lender. (The bank that brings Party A and Party B together may be a 4th party). The position of the 3 parties is shown in Figure 8.1.

Figure 8.1

Swap Parties



Party A will pay MIBOR + 2% to its lender, out of which, it will receive MIBOR from Party B under the swap. Thus, it is no longer exposed to the fluctuations in MIBOR. If MIBOR rises, it will receive more from Party B and pay the amount to its lender.

Party A's cost of funds is the 2% additional it needs to pay its lender, plus the 8% it has to pay Party B i.e. 10% fixed.

Party B, on the other hand, is assured of 8% fixed interest income, from Party A. In return it has to pay MIBOR, which it expects will fall.

The actual cash flows of the parties are shown in Table 8.1 (the MIBOR rates are assumed).

Table 8.1

Cash Flows of Swap Counter Parties

Date	Mibor	Party A's Cashflows				Party B's Cashflows		
		Interest to Lender	Pay on Swap	Receive on swap	Net Flow	Pay on Swap	Receive on Swap	Net Flow
30-Jun-13	9.00%	-5,50,000	-4,00,000	4,50,000	**-5,00,000**	-4,50,000	4,00,000	**-50,000**
31-Dec-13	9.25%	-5,62,500	-4,00,000	4,62,500	**-5,00,000**	-4,62,500	4,00,000	**-62,500**
30-Jun-14	8.75%	-5,37,500	-4,00,000	4,37,500	**-5,00,000**	-4,37,500	4,00,000	**-37,500**
31-Dec-14	7.90%	-4,95,000	-4,00,000	3,95,000	**-5,00,000**	-3,95,000	4,00,000	**5,000**

Party A's net interest cost is Rs. 5 lakh every 6 months i.e. Rs. 10 lakh p.a. On the Rs. 1 crore notional principal, it works out to 10%.

Party B's benefits if MIBOR goes below 8%.

A few points to note:

- Party A's lender will continue receiving MIBOR + 2% from Party A. The swap is a separate transaction between Party A and Party B. Party A's lender may not even be aware of the swap.
- The parties avoid multiple payments by netting. Thus, either Party A will pay Party B or Party B will Party A, depending on MIBOR.

8.3 Valuing Interest Rate Swaps

8.3.1 Valuation based on Bonds

An interest rate swap has only interest payments. Since no principal is paid, the cash flows are not like a normal coupon bearing bond. However, by assuming a receipt and payment on maturity, the cash flows can be made to look like a coupon bearing bond.

Receipt and payment of the same amount on maturity will net each other. Therefore, it does not affect the economics of the swap in any way, but aids valuing the swap as a bond.

If Party A were to pay Rs. 1 crore on maturity, its payments are like an 8% bond. Receipt of Rs. 1 crore on maturity transforms the profile of its receipts into a bond yielding Mibor. Thus, Party A's position is that of a 8% bond liability (fixed) and a Mibor bond asset (floating). It has effectively sold a fixed rate bond and purchased a floating rate bond.

The value of the Swap for Party A can be defined as:

$\text{Valuation}_{\text{Floating}} - \text{Valuation}_{\text{Fixed}}$

The two bonds can be valued on yield to maturity (YTM) basis like any debt security.

The swap is normally initiated at prevailing interest rates. Therefore, initially, the value of the swap would be zero.

Suppose MIBOR were to rise, subsequently. When yields go up, fixed rate instruments lose value. Therefore, Valuation $_{Fixed}$ would go down. This will raise the value of the swap for Party A.

Party B's position is reverse. The value of the swap for Party B is

Valuation $_{Fixed}$ – Valuation $_{Floating}$

Suppose MIBOR were to fall, subsequently. When yields go down, fixed rate instruments gain value. Therefore, Valuation $_{Fixed}$ would go up. This will raise the value of the swap for Party B.

In this discussion on impact of changes in MIBOR, the role of Valuation $_{Floating}$ in determining the value of the swap has not been highlighted. There is a reason for this. If MIBOR were to change, the floating rate instrument will in any case pay the changed rate for the next interest cycle. Therefore, it will be at par on the next interest payment date. The impact of changes in MIBOR on Valuation $_{Floating}$ is therefore negligible, if not zero. Therefore, it is the changes in Valuation $_{Fixed}$ that drive the value of the swap.

Suppose that on Jan 1, 2014, the 1-year yield is at 8.5%. Party A has to pay at only 8% p.a. for 1 year under the swap. Thus, the swap is beneficial to Party A. How much is that benefit? The calculation is shown in Table 8.2.

<u>Table 8.2</u>

Valuation of Fixed Rate Commitment of Party A under Swap

Date	Payable	Discount Factor @ 8.5%	Present Value of Payment
30-Jun-14	-4,00,000	0.95923261	-3,83,693
31-Dec-14	-1,04,00,000	0.92012721	-95,69,323
Total			**-99,53,016**

Note: On Dec 31, 2014 Rs. 1 crore notional payment is added for the bond valuation
Discount factor Is calculated as "1÷4.25%" for June 30; "1÷(1+4.25%)^2" for Dec 31
PV of Payment = Payable X Discount Factor

While Valuation $_{Floating}$ remains at Rs. 1 crore, the Valuation $_{Fixed}$ is now Rs. 99,53,016.

The value of swap for Party A is Valuation $_{Floating}$ – Valuation $_{Fixed}$

i.e. Rs. 1,00,00,000 – Rs. 99,53,016

i.e. Rs. 46,984.

Party B has lost out on the Swap. The value of the swap for Party B is Valuation $_{\text{Fixed}}$ – Valuation $_{\text{Floating}}$

i.e. Rs. 99,53,016 – Rs. 1,00,00,000

i.e. –Rs. 46,984.

8.3.2 Valuation based on Forward Rate Agreements (FRAs)

An alternate approach to valuing swaps is on the basis of FRAs. FRA is an agreement to lend money on a future date at an interest rate that is decided today. Typically, this is derived from the market as discussed below.

In the earlier example, the 1 year yield on Jan 1, 2014 was 8.5%. Suppose that the 6-month yield on the same date was 8%. What then, is the yield for the period July 1, 2014 to Dec 31, 2014.

Rs. 100 invested on Jan 1, 2014 @ 8% for 6 months would have been worth Rs. 104 on June 30, 2014.

Rs. 100 invested on Jan 1, 2014 @ 8.5% for 12 months would have been worth Rs. 108.50 on Dec 31, 2014.

Thus, it can be said that Rs. 104 invested on June 30, 2014 is worth Rs 108.50 on Dec 31, 2014. This translates to a return of (108.50 – 104) ÷ 104 i.e. 4.327% for 6 months. This is equivalent to 8.654% for a year.

Thus, 8% p.a. return for the first 6 months, and 8.654% p.a. return for the next 6 months is equivalent to a return of 8.5% p.a. for the entire 12 month period.

The bond pricing example used a single 8.5% yield for calculating the present value of the cash flows in the swap for the entire swap period. The FRA approach uses different discount rates for each cash flow. This more complex approach is often used for valuing exotic swaps.

8.4 Currency Swap

In a currency swap, the two streams of payments are in different currencies.

Suppose Party D and Party R, are counter-parties to a 2-year swap. Party D agrees to pay Party R, 3% p.a., semi-annually, on a notional principal of USD1mn. In return, Party R commits to pay Party D 7% p.a., semi-annually, on a notional principal of Rs. 5 crore. When the swap is initiated, Party R pays USD1mn to Party D; and receives Rs. 5 crore from Party D. On maturity, Party D pays USD1mn to Party R, and receives Rs. 5 crore from Party R.

Party R’s cash flows are shown in Table 8.3.

Table 8.3

Party R's Cash Flows

Date	USD mn	Rs. Cr.
30-Jun-13	-1.00	5.00
31-Dec-13	0.03	-0.35
30-Jun-14	0.03	-0.35
31-Dec-14	1.03	-5.35

Party D's cash flows are shown in Table 8.4.

Table 8.4

Party D's Cash Flows

Date	USD mn	Rs. Cr.
30-Jun-13	1.00	-5.00
31-Dec-13	-0.03	0.35
30-Jun-14	-0.03	0.35
31-Dec-14	-1.03	5.35

Party R has thus taken up a USD asset and a Rupee liability. Party D has done the reverse viz. assumed a USD liability and a Rupee asset.

Parties R & D are exchanging interest rates on fixed basis. The swap is 'Fixed for Fixed'. Similarly, 'Fixed for Floating' is also possible, where interest rate for one leg is in LIBOR or MIBOR. Alternatively, it can be 'Floating for Floating', where one leg may be in LIBOR and the other may be in MIBOR.

8.5 Valuing Currency Swaps

As with interest rate swaps, currency swaps too are valued like bonds. The examples in Tables 8.3 and 8.4 provided for exchange of principal between the parties at the end. Since the cash flows already resembles a bond structure, there is no need to make any special adjustment for payment of notional principal.

Party R's position can be viewed as purchase of a USD Bond yielding 3% p.a. and sale of a Rupee bond yielding 7%. Party D's position is the reverse viz. sale of a USD Bond and purchase of a rupee bond, yielding 3% and 7% respectively.

The value of swap for Party R is therefore

$\text{Valuation}_{\text{USD Bond}} - \text{Valuation}_{\text{Rupee Bond}}$.

The value of swap for Party D is

$\text{Valuation}_{\text{Rupee Bond}} - \text{Valuation}_{\text{USD Bond}}$

Each party is likely to convert the calculated values to their local currency. Party R will benefit from the swap, on account of exchange rate changes, if the USD strengthens against the rupee. Party D will be better off if the rupee strengthens against the USD.

8.6 Swaption

A swaption is an option to enter into a swap.

Suppose that a borrower has entered into a 5-year loan agreement where he has to pay MIBOR + 2%. He is prepared to take interest risk for 2 years. But, he is worried about interest rates after 2 years.

At the end of 2 years, he can do a swap to pay fixed and receive floating. The only problem is that the terms of the swap will depend on the interest rate scenario at that time.

Instead, he can enter into a swaption today. This will give him the right, but not an obligation to do the swap after 2 years. The terms of the underlying swap are decided today, for which he will have to pay an option premium. The borrower, in this case, can be said to have gone long on a call option (because he will receive floating under the swap) on the swap.

Suppose that the original loan agreement was on fixed interest rate basis, and the subsequent swap is for the borrower to pay floating and receive fixed. If the borrower does a swaption, he is said to have gone long on a put option (because he will pay floating under the swap) on the swap.

Self-Assessment Questions

- Which of the following roles does a bank perform in swaps?
  - Broker
  - Dealer
  - **Either of the above**
  - None of the above
- Swaps cover
  - Interest Rate
  - Currency
  - Either of the above
  - **Interest rates, currency or commodities**
- Currency swaps are done with interest
  - Floating for Floating
  - Floating for Fixed
  - Fixed for Fixed
  - **Any of the above**
- The FRA approach to interest rate swap valuation uses different discount rates for each cash flow.
  - **True**
  - False
- A Swaption is a swap between two option contracts
  - True
  - **False**

Chapter 9 Embedded Options in Debt Instruments

9.1 Warrants

The holder of a call option is entitled to the underlying security at a certain price. The contract is created by the stock exchange. The holder pays an option premium to the writer of the call option.

A warrant too entitles the holder to an underlying security at a certain price. However, unlike a call option, the warrant is issued by the company concerned. If the warrant is exercised, the issuing company will issue fresh securities, thus affecting the balance sheet of the company and the stake of other investors in the company.

Warrants are often attached to a debt security, to make it more attractive for the investor, or reduce the interest cost of the issuer. Thus, the investor does not pay a separate price for acquiring the warrant (though he will have to pay the agreed price for the security if he chooses to exercise the warrant).

Further, the warrant may not be traded in the stock market. Therefore, it does not have the liquidity and price discovery features normally associated with exchange-created call options.

In the absence of a transparent pricing of the warrant in the market, a round-about route should ideally be adopted for its valuation. Some other similar company, which has not issued any warrants, is to be taken as a benchmark. Call option on the benchmark company's stock can be valued using Black Scholes or binomial models.

Since exercise of the warrant will lead to issue of new securities, the value of the underlying securities is likely to be pulled down. The extent of such value depletion would depend on number of new securities issued. Therefore, the warrant cannot be valued at the same price as the call option of the benchmark company. The benchmark company's call option valuation needs to be adjusted to a factor of $q \div (p+q)$, where

'q' is the number of shares issued by the warrant-issuing company (that account for existing share capital)

'p' is the number of warrants outstanding (i.e. number of new shares that will be issued if all the warrants are exercised)

Suppose, the benchmark company's call option is valued at Rs. 10, and the warrant issuing company has issued 3 lakh shares, plus warrants that can be translated into 2 lakh additional shares.

q = 3 lakh

p = 2 lakh

The warrant will be valued at $\{3 \div (2+3)\}$ X Rs. 10 i.e. Rs. 6.

The round-about method does post its challenge in terms of identifying a benchmark company. Therefore, the market values warrants like options on stock of the warrant-issuing company (and not benchmark company). The Black Scholes call option valuation on this basis is a reasonable approximation of the true value of the warrant, except when the number of warrants is a large proportion of the number of existing shares, and the options are deeply out-of-the-money.

9.2 Convertible Bonds

A convertible bond entitles the holder to either get the principal back, or get them converted into a certain number of shares of the company. Conceptually, it can be viewed as a combination of a non-convertible bond and a warrant to convert the redemption proceeds into a certain number of shares. Depending on the price of the underlying and the exercise price, the investor will decide between receiving the money back and using the money to acquire the agreed number of shares.

Convertible bonds are therefore valued as a combination of non-convertible bond and a warrant.

Suppose a stock which is trading at Rs. 20, has annualised volatility of 15%. A 3-month option on that stock has exercise price of Rs. 17. Risk-free rate is 8% p.a. The company has issued 10% convertible bonds of Rs. 17,000 each. These are due to mature in 3 months. Interest is paid quarterly. The investor has the option to convert each bond into 1,000 shares at Rs. 17. In the normal course, the company would have paid 12% for a 3-month borrowing.

Interest payable on the bond at the end of 3 months would be Rs. 17,000 X 10% X (3÷12) i.e. Rs. 425.

Thus, redemption amount would be Rs. 17,000 + Rs. 425 i.e. Rs. 17,425.

The company’s borrowing rate for pure debt of 3 months is 12% p.a. i.e. 3% for the 3 months to maturity.

Valuation as a non-convertible bond would entail discounting the redemption amount by the company’s borrowing rate.

Non-convertible value = Rs. 17,425 ÷ (1.03)

i.e. **Rs. 16,917.48.**

The warrant is similar to the call option for 1 share that was described in Example 5.1. In that example, the call option was valued at Rs. 3.34. Since the debenture is convertible into 1,000 shares, the option valuation is 1,000 X Rs. 3.34 i.e. **Rs. 3,340**.

The value of the convertible bond = Rs. 16,917.48 + Rs. 3,340

i.e. **Rs. 20,257.48**

9.3 Call Option in a Debt Security

Call option, as already discussed, gives the holder of the option, the right to buy a security at a specified price. The holder of the call pays an option premium to the writer of the call.

Debt securities are often issued with an option to the issuer to call back the security, as provided in the terms of issue of the debt security.

For example, Financial Institution P may offer a 10% debenture of 5 years, with call option at par at the end of 3 years. This means that P has the option of redeeming the debenture, at par, at the end of 3 years, instead of its normal term of 5 years.

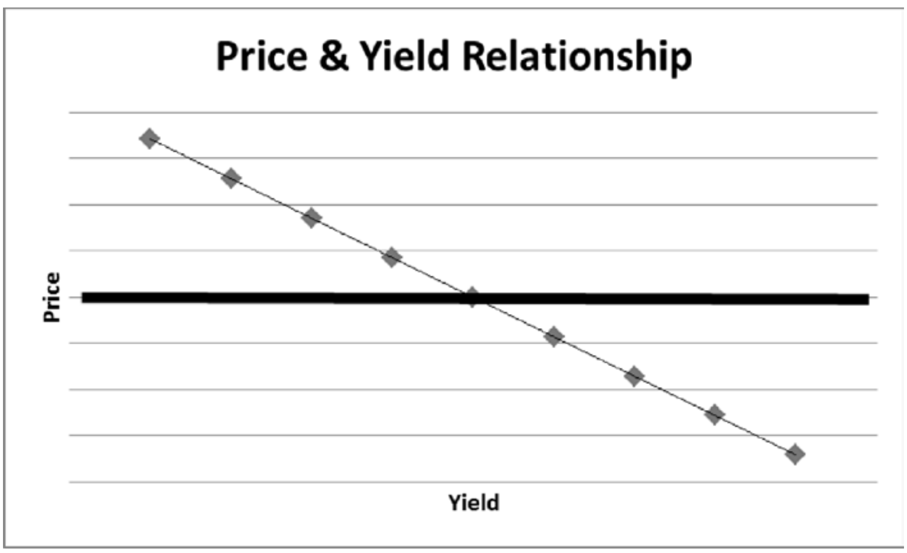
At the end of 3 years, if P finds that it can raise money for 2 years (the balance tenor of the debenture at that stage) at say, 9%, it will choose to refinance its liabilities i.e. it will redeem the 10% debenture, and meet the redemption requirement by making a fresh issue of 9% debentures of 2 years. It will, thus, save 1% p.a. in interest cost for 2 years (The actual saving may be lower because the fresh issue of debentures would entail some costs).

On the other hand, if at the end of 3 years, P can get 2-year money only at 10% or higher, then it would not be sensible for P to exercise its call option. Thus, the call is most likely to be exercised, if yields in the market were to go down.

In the normal course, if yields in the market were to go down, then price of fixed interest rate debt securities would go up (Thin sloping line in Figure 9.1). Thus, the investor can earn a capital gain.

The call option or the issuer limits this upside potential for the investor. The thick horizontal line in Figure 9.1 is the call price. It is unlikely that the price will go above this line, because the issuer will call back the security at the call price, if yields in the market decline to that extent.

Figure 9.1



A debenture of 5 years, with call option at the end of 3 years, effectively has a swaption built in. The issuer has the option to swap his interest rate liability to the then prevailing interest rates, at the end of 3 years.

9.4 Put Option in a Debt Security

Put option, as already discussed, gives the holder of the option, the right to sell a security at a specified price. The holder of the put pays an option premium to the writer of the put.

Debt securities are often issued with an option to the investor to put the security back to the issuer, as provided in the terms of issue of the debt security.

For example, an investor in 10% debentures of 5 years issued by Financial Institution P may have a put option at par at the end of 3 years. This means that the investor has the option of seeking redemption of the debenture, at par, at the end of 3 years, instead of its normal term of 5 years.

At the end of 3 years, if the investor finds that he can invest for 2 years (the balance tenor of the debenture at that stage) at say, 11%, he will choose to redeem the 10% debenture. He will re-invest the proceeds in a fresh issue of 11% debentures of 2 years. Thus, he will gain 1% p.a. in interest income for 2 years.

On the other hand, if at the end of 3 years, yields are at 10% or lower, then it would not be sensible for the investor to exercise his put option. Thus, the put is most likely to be exercised, if yields in the market were to go up.

In the normal course, if yields in the market were to go up, then price of fixed interest rate debt securities would go down (Thin sloping line in Figure 9.1). Thus, the investor may book a capital loss.

The put option with the investor limits his downside. Suppose the thick horizontal line in Figure 9.1 is the put price. It is unlikely that the price of the debenture will go below this line, because the investor can put it back to the issuer at the put price, if yields in the market increase to that extent.

9.5 Put & Call Option in a Debt Security

An investor in a debenture that has a call option is at a disadvantage as compared to an investor in a debenture that does not have the call option. This is particularly so, if the call is at par. The investor in the debenture with call option would therefore expect some compensation, either in terms of higher interest rate or a redemption premium, if the call is exercised.

Similarly, the issuer would expect to offer a lower interest rate on a debenture that has a put option, as compared to another debenture that does not have a put option. Else, the issuer would at least seek to structure the instrument with the redemption being at a discount, if the put is exercised.

Issuer may balance this by offering a call and put in the instrument on the same date. In that case, the instrument is likely to be redeemed early. Either yields in the market may go down, in which case the call will get exercised; or yields in the market may go up, in which case the put will get exercised.

9.6 Caps

In a floating rate instrument, the interest payable by the issuer keeps going up with the benchmark. Issuers who wish to put a limit to their interest cost will set a "cap". For example, a term of the issue would be that interest is payable at MIBOR + 2%, subject to a cap of 12%.

In that case, if MIBOR were to go beyond 10% to say, 11%. Although MIBOR + 2% would mean 13%, the cap on interest rate at 12% would be applicable. The company will pay 12%.

In the above case, the cap was embedded in the debenture. It was part of the terms of the debenture issue. "Caps" can also be purchased.

Suppose the issuer in the above case issued an uncapped debenture. Later, it got worried about rising MIBOR, and wanted to limit its interest cost. It will look for someone who is prepared to sell a cap. Let us assume that the issuer is able to buy a cap at 12%.

If MIBOR goes to 11%, the investor in the debenture will receive 11% + 2% i.e. 13%. But the cap seller will pay the issuer 13% – 12% i.e. 1%. Thus, the effective cost of the issuer stays at 12% (plus whatever it has to pay the cap seller for the arrangement).

So long as MIBOR remains below 10%, the effective interest rate payable on the debenture would remain below 12%. The cap seller will not have to pay the issuer anything. The consideration received for selling the cap to the cap buyer will be an income for the cap seller.

In option terminology, the receipts for the cap-buyer from the cap can be defined as Max (0, R – k),

where

R is the interest payable on the debenture

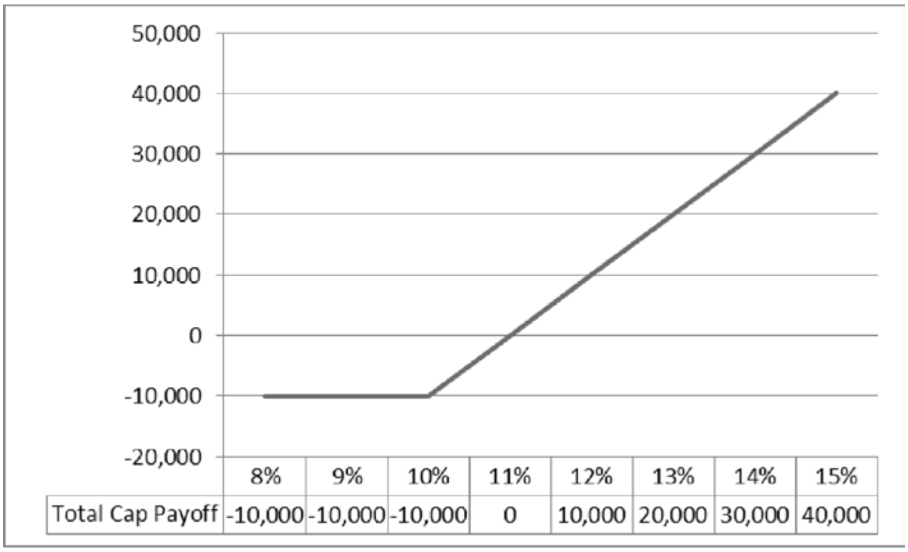
K is the cap rate

The cap is thus like a call option, where the cap buyer benefits if interest rates go above a level; else he does not receive anything under the cap. Only the premium for purchase of cap needs to be borne.

The pay-off matrix for the cap buyer and cap seller are shown in Figures 9.2 and 9.3. Assumption is debenture issue of Rs. 10 lakh, and per period premium of Rs. 10,000.

Figure 9.2

Payoff for Cap Buyer



Cap buyer incurs the premium of Rs. 10,000 per period.

So long as MIBOR is below 10%, the cap buyer receives nothing from the cap seller. The premium is the net loss.

When MIBOR touches 11%, the cap buyer will receive 1% on Rs. 10 lakh i.e. Rs. 10,000 from the cap seller. This offsets the option premium of Rs. 10,000. Therefore the net pay off is nil.

Above a MIBOR level of 11%, the cap buyer starts seeing a profit from the cap.

The same economics will work on each interest payment date. Thus, the issuer would have bought a series of caps; each of them is called a "caplet". A Cap agreement can be seen as a series of caplets.

The pay-off for the cap-seller is the reverse, as seen in Figure 9.3.

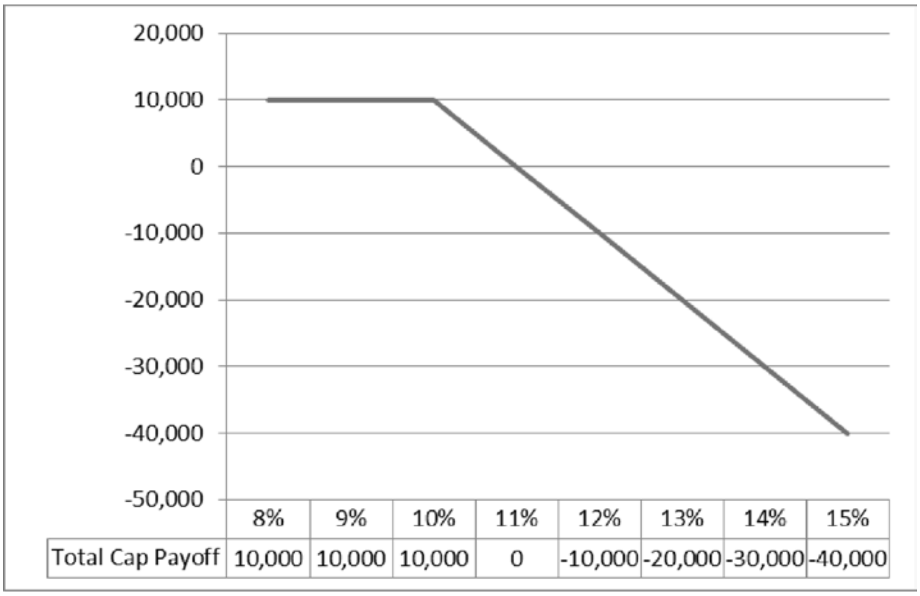
Cap seller receives the premium of Rs. 10,000 per period.

So long as MIBOR is below 10%, the cap seller pays nothing to the cap buyer. The premium is the net profit.

When MIBOR touches 11%, the cap seller will pay 1% on Rs. 10 lakh i.e. Rs. 10,000. This offsets the option premium income of Rs. 10,000. Therefore the net pay off is nil.

Beyond a MIBOR level of 11%, the cap seller starts seeing a loss from the cap. Higher the MIBOR level, greater the loss.

Figure 9.3



9.7 Floors

Just as "cap" protects the issuer, "floor" protects the investor in a floating rate debenture. As MIBOR goes lower and lower, the investor in the above MIBOR +2% bonds will receive lesser and lesser interest.

If we presume that MIBOR will not go below 0%, the investor has a natural floor at 2%. Suppose that he wants a higher floor at say, 7%.

One option is to go for a debenture that has a floor embedded at 7%. If that is not available, then he can buy a floor from a floor seller. Suppose he does that. He buys a floor at, say, Rs. 10,000 per annum.

So long as MIBOR is at 5% or above, the investor receives nothing from the floor seller. He only bears the option premium.

Suppose MIBOR goes lower than 5% to say, 4%. The investor will receive 6% from the issuer of those debentures. But he will also receive 1% from the floor-seller. Thus, he is assured a total income of 7%.

In option terminology, the receipts for the floor-buyer from the floor can be defined as Max (0, K – R),

where

R is the interest payable on the debenture

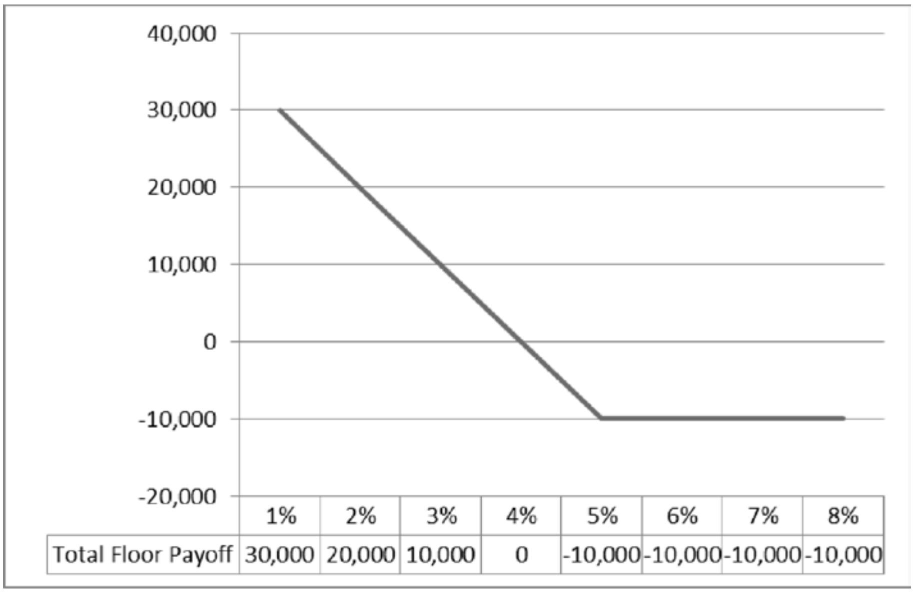
K is the floor rate

The floor is thus like a put option, where the floor buyer benefits if interest rates go below a level; else he does not receive anything under the floor. Only the premium for purchase of floor needs to be borne.

The pay-off matrix for the floor buyer and floor seller are shown in Figures 9.4 and 9.5. Assumption is debenture investment of Rs. 10 lakh, and per period premium of Rs. 10,000.

<u>Figure 9.4</u>

Payoff for Floor Buyer



Cap buyer incurs the premium of Rs. 10,000 per period.

So long as MIBOR is 5% or above, the floor buyer receives nothing from the floor seller. The premium is the net loss.

When MIBOR touches 4%, the floor buyer will receive 1% on Rs. 10 lakh i.e. Rs. 10,000 from the floor seller. This offsets the option premium of Rs. 10,000. Therefore the net pay off is nil.

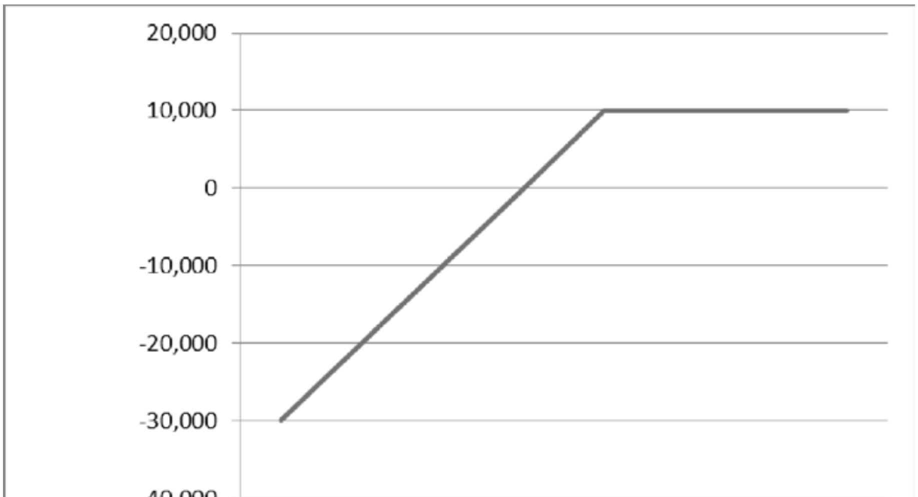
Below a MIBOR level of 4%, the floor buyer starts seeing a profit from the floor.

The same economics will work on each interest payment date. Thus, the invester would have bought a series of floors; each of them is called a "floorlet". A Floor agreement can be seen as a series of floorlets.

The pay-off for the floor-seller is the reverse, as seen in Figure 9.5.

Floor seller receives the premium of Rs. 10,000 per period.

Figure 9.5



	1%	2%	3%	4%	5%	6%	7%	8%
Total Floor Payoff	-30,000	-20,000	-10,000	0	10,000	10,000	10,000	10,000

So long as MIBOR is 5% or above, the floor seller pays nothing to the cap buyer. The premium is the net profit.

When MIBOR touches 4%, the floor seller will pay 1% on Rs. 10 lakh i.e. Rs. 10,000. This offsets the option premium income of Rs. 10,000. Therefore the net pay off is nil.

Below a MIBOR level of 4%, the cap seller starts seeing a loss from the cap. Lower the MIBOR level, greater the loss.

9.8 Collars

A collar is a simultaneous position on floor (purchase / sale) and cap (sale / purchase) on the same bench mark (with the same interest payment dates).

The idea behind the collar is that on purchase of a cap / floor, an option premium is to be paid; this can be offset by receiving option premium on sale of a floor / cap. The cap and floor can be set at a level where the option premia receivable and payable match. This will make it a zero cost collar.

Debentures issued with a floor and cap, effectively have an embedded collar. The issuer has purchased a cap (from the investor) and sold a floor (to the investor). With this collar, the issuer ensures that his borrowing cost will remain between the floor and the cap.

If the debenture does not have an embedded cap, floor or collar, the investor can buy a floor and sell a cap. Depending on the floor and cap rates, he can structure a zero cost collar for himself.

Self-Assessment Questions

- Company A has issued 10 lakh shares and warrants, which on exercise will lead to another 2 lakh shares. The benchmark company X's call options are valued at Rs. 4. What should be the value of Company A's warrants?
  - Rs. 4
  - **Rs. 3.33**
  - Rs. 4.80
  - Rs. 4.17
- Company X has issued 8% Convertible debentures of Rs. 10,000 each. Interest is payable semi-annually. Each debenture is convertible into 10 shares at the option of the investor. Similar debentures that are non-convertible offer yield of 12% p.a in the market. Call options of the company with strike of Rs. 1000 are trading at Rs. 4.50 per share. The convertible debentures represent a small portion of Company X's share capital. What is the value of the convertible debenture?
  - **Rs. 9,856.32**
  - Rs. 9,815.82
  - Rs. 10,045
  - Rs. 10,004.50
- Debentures with a call option have an embedded swaption.
  - **True**
  - False
- Call option is likely to be exercised if yields were to go up.
  - True
  - **False**
- Caps and floors are a feature of fixed rate debentures
  - True
  - **False**

Chapter 10 Credit Risk & Derivatives

10.1 Credit Risk & Rating

Parties may have exposure to each other in several situations. For instance,

- Party B may buy bonds issued by Party S. Party B is exposed to a credit risk on Party S, until the bonds are redeemed.
- Party A may loan money to Party D that is repayable in a few years.
- Parties P and Q may enter into a swap. The examples given earlier showed separately, the amounts payable on each leg of the swap. In practice, a single net payment is made by one party to the other, depending on how the interest rates and or exchange rates move. The party which is to receive the net payment is exposed to a credit risk on the swap counter-party.

Credit rating agencies such as Crisil, ICRA, Care and Duff & Phelps are in the business of evaluating credit risk. They evaluate borrowing programs (such as a specific series of debenture issue) and award a credit rating, which is denoted by a symbol.

The credit rating symbols are different for different types of borrowings, such as short term or long term. Table 10.1 shows the long term credit rating symbols. The rating agency may use '+' or '-' against a rating symbol, to show marginally better or worse ratings.

Where a rating is not based on balance sheet of the borrower but a specific credit enhancement structure that has been put in place, the symbol is succeeded by 'SO' which stands for Structured Obligation.

Issuers with poor credit rating offer higher rates of interest on their debt issues. In other words, they offer higher yield spreads (spread over sovereign yields). This is an attraction for investors to go beyond sovereign securities and take the credit risk. However, it is important for the investor to judge the credit risk prudently. Credit risk can cause serious damage to the balance sheet of the investor, if there is a default.

Even if there is no default, deterioration in the credit rating of the issuer can raise yield expectations from that company in the market. When the yield expectation goes up, the debt security will lose value. Consequently, the investor may have to book mark to market losses.

Table 10.1

Long Term Credit Rating Symbols

AAA (highest safety)	Instruments with this rating are considered to have the highest degree of safety regarding timely servicing of financial obligations. Such instruments carry lowest credit risk.
AA (High safety)	Instruments with this rating are considered to have high degree of safety regarding timely servicing of financial obligations. Such instruments carry very low credit risk.
A (Adequate safety)	Instruments with this rating are considered to have adequate degree of safety regarding timely servicing of financial obligations. Such instruments carry low credit risk.
BBB (Moderate safety)	Instruments with this rating are considered to have moderate degree of safety regarding timely servicing of financial obligations. Such instruments carry moderate credit risk.
BB (Moderate risk)	Instruments with this rating are considered to have moderate risk of default regarding timely servicing of financial obligations.
B (High risk)	Instruments with this rating are considered to have high risk of default regarding timely servicing of financial obligations.
C (Very high risk)	Instruments with this rating are considered to have very high risk of default regarding timely servicing of financial obligations.
D (Default)	Instruments with this rating are in default or are expected to be in default soon.

10.2 Default History & Recovery Rates

Credit rating companies also study default history viz. given a credit rating, what was the experience in terms of default and in how many years after the rating. For example, AAA may not have defaulted within 2 years of the rating; however 0.2% of AAA companies default in 3 years; 0.3% of AAA companies default in 4 years and so on.

When a company goes bankrupt, how much were creditors able to recover. This is given by the Recovery Rate. For example, the recovery rate may be 40% for secured debentures, 30% for unsecured debentures, 20% for subordinate debt etc.

10.3 Calculation of Default Risk

There are various ways to measure default risk in a bond. Bond valuations in the market are commonly used for this purpose. Two approaches are shown below:

10.3.1 Simple Approach

Suppose a bond is trading at 13%, while risk-free rate is at 9%. In the event of default, a recovery of 30% can be expected.

The yield spread of 13% – 9% i.e. 4% is a compensation for the risk of losing money.

Since recovery rate in the event of default is 30%, the loss on default is 1 – 30% i.e. 70%

The default risk can be calculated as Yield spread ÷ Loss on default

i.e. 4% ÷ 70%

i.e. 5.71%

10.3.2 Present Value Approach

Suppose that on January 1, 2013, Company X has issued 12% bonds of face value Rs. 100. Interest is payable semi-annual. The tenor is 5 years.

Soon after issue, the continuously compounded yields in the market are 11% p.a. for bonds of Company X and 8% for risk-free bonds.

Recovery in the event of default is 30%. What is the default rate for Company X's bonds, according to the bond market?

At the first stage, let us calculate the price of Company X's bonds at its continuously compounded market yield of 11%. Let us also work out the theoretical price of Company X's bonds at the continuously compounded risk-free rate of 8%. The calculations are shown in Table 10.1.

<u>Table 10.1</u>

Valuation of Company X's Bonds

Time	Cash Flow	e^{-rt} for Bond	PV Bond	$e^{-rf\,t}$ for Risk-free	PV Risk-free
0.5	6	0.9464852	5.68	0.9607895	5.76
1.0	6	0.8958342	5.38	0.9231164	5.54
1.5	6	0.8478938	5.09	0.8869205	5.32
2.0	6	0.8025189	4.82	0.8521439	5.11
2.5	6	0.7595723	4.56	0.8187309	4.91
3.0	6	0.7189239	4.31	0.7866280	4.72
3.5	6	0.6804508	4.08	0.7557839	4.53
4.0	6	0.6440366	3.86	0.7261492	4.36
4.5	6	0.6095711	3.66	0.6976765	4.19
5.0	106	0.5769500	61.16	0.6703202	71.05
Total			**102.59**		**115.50**

The valuation on risk-free basis is 115.50, while the bonds are trading at Rs. 102.59. The difference, Rs. 115.50 – Rs. 102.59 i.e. Rs. 12.91 is obviously, the expected loss from default in Company X's bonds, as per the bond market.

Company X can default on its bonds any day during the 5 years. For simplicity in calculation, let us do the workings on each interest payment date, assuming that the immediate coupon will be received. Let us also assume that the default probability is P on each interest payment date. The expected loss from default, as per present value calculations are shown in Table 10.2.

To understand the calculations, let us examine the position at Time 4. Expected cash flows are:

- Coupon of Rs. 6 at Time 4 (Risk-free discount factor for immediate payment = 1)
- Coupon of Rs. 6 at Time 4.5 (Risk-free discount factor for payment in 6 months = 0.9607895)
- Coupon of Rs. 6 + Principal of Rs. 100 at Time 5 (Risk-free discount factor for payment in 1 year = 0.9231164)

Value of the bond on risk-free basis is therefore (6 X 1) + (6 X 0.9607895) + (106 X 0.9231164) i.e. Rs. 109.62.

Since 30% of principal is expected to be recovered if the company goes bankrupt, the loss on default would be Rs. 109.62 – Rs. 30 i.e. Rs. 79.62.

We need to find the present value of that loss, for which the risk-free discount factor for Year 4 is 0.7261492. The present value of the Year 4 loss is therefore Rs. 76.62 X 0.7261492 i.e. Rs. 57.82.

Since probability of default is P, the present value of expected loss is Rs. 57.82P.

The total of similar calculations for each interest payment date is 627.67P. This represents the expected loss at Time 0, which we calculated as Rs. 12.91. Therefore,

627.67P = 12.91

P = 12.91 ÷ 627.67 i.e. 2.06%.

The probability of default on Company X's bonds is 2.06%, according to the bond market.

Table 10.2

Expected Loss from Default (Present Value Approach)

Time (t)	Default Probability	Recovery if Default	Value at time 't' at risk-free rate	Loss if default at time 't'	Discount factor for each loss at risk-free rate	PV of loss	PV of expected loss
0.5	P	30	120.22	90.22	0.9607895	86.68	86.68 P
1.0	P	30	118.88	88.88	0.9231164	82.05	82.05 P
1.5	P	30	117.48	87.48	0.8869205	77.59	77.59 P
2.0	P	30	116.03	86.03	0.8521439	73.31	73.31 P
2.5	P	30	114.52	84.52	0.8187309	69.20	69.2 P
3.0	P	30	112.95	82.95	0.7866280	65.25	65.25 P
3.5	P	30	111.32	81.32	0.7557839	61.46	61.46 P
4.0	P	30	109.62	79.62	0.7261492	57.82	57.82 P
4.5	P	30	107.84	77.84	0.6976765	54.31	54.31 P
Total						**627.67**	**627.67 P**

10.4 Mitigating Credit Risk

There are various ways to mitigate credit risk. For example:

- Creating a charge on fixed assets of adequate value
- Seeking pledge of the company's shares having voting rights
- Seeking a guarantee from the promoters
- Creating a structured obligation, where the customers of the borrower deposit money into a specific bank account over which the lender has an escrow facility
- Buying a credit default swap
- Sell the credit risk through alternate structures like Collateralised Debt Obligation (CDO).

10.5 Credit Default Swaps

One approach to handle credit risk is by buying protection against the credit risk, through a credit default swap (CDS).

A CDS has two parties – buyer and seller. The buyer (Party B in the earlier example) pays premium to the seller (say, Bank X) for the protection. In return, the seller promises to compensate the buyer, if the issuer (Party S in the earlier example) of the underlying bond defaults on the payments.

Bank X is supposed to do a proper credit review of Party S before selling a CDS to Party B. CDS sold without proper credit risk assessment led several CDS sellers to bankruptcy in the developed markets in the last few years. RBI has therefore imposed a strict regulatory regime for the product. The key regulations are as follows:

- Participants in the market are classified into two:
  - o *Users*

    Commercial Banks, Primary Dealers (PDs), Non-Banking Finance Companies (NBFCs), Mutual Funds, Insurance Companies, Housing Finance Companies, Provident Funds, Listed Corporates, Foreign Institutional Investors (FIIs) and any other institution specifically permitted by the Reserve Bank.

    These entities are permitted to buy credit protection (buy CDS contracts) only to hedge their underlying credit risk on corporate bonds.

    Such entities are not permitted to hold credit protection without having eligible underlying as a hedged item.

    Users are also not permitted to sell protection and are not permitted to hold short positions in the CDS contracts. However, they are permitted to exit their bought CDS positions by unwinding them with the original counterparty or by assigning them in favour of buyer of the underlying bond.
  - o *Market Makers*

    Commercial Banks, standalone PDs, NBFCs having sound financials and good track record in providing credit facilities and any other institution specifically permitted by the Reserve Bank.

    Insurance companies and Mutual Funds would be permitted as market-makers subject to their having strong financials and risk management capabilities as prescribed by their respective regulators (IRDA and SEBI) and as and when permitted by the respective regulatory authorities.

    These entities are permitted to quote both buy and/or sell CDS spreads. They are permitted to buy protection without having the underlying bond.
- All CDS trades need to have an RBI regulated entity on at least one side of the transaction.
- Detailed eligibility criteria have been specified for every category of market maker. In case a market-maker fails to meet one or more of the eligibility criteria subsequent to commencing the CDS transactions, it would not be eligible to sell new protection. As regards existing contracts, such protection sellers would meet all their obligations as per the contract.
- The party against whose default, protection is bought and sold through a CDS is called the reference entity. It should be a single legal resident entity [the term resident is as defined in Section 2(v) of Foreign Exchange Management Act, 1999] and the direct obligor for the reference asset/obligation and the deliverable asset/ obligation.

- CDS is allowed only on the following reference obligations:
  - o Listed corporate bonds
  - o Unlisted but rated bonds of infrastructure companies.
  - o Unlisted/unrated bonds issued by the SPVs set up by infrastructure companies.

    Such SPVs need to make disclosures on the structure, usage, purpose and performance of SPVs in their financial statements.
- The reference obligations are required to be in dematerialised form only.
- The reference obligation of a specific obligor covered by the CDS contract should be specified a priori in the contract and reviewed periodically for better risk management.
- Protection sellers should ensure not to sell protection on reference entities/obligations on which there are regulatory restrictions on assuming exposures in the cash market such as, the restriction against banks holding unrated bonds, single/group exposure limits and any other restriction imposed by the regulators from time to time.
- Users cannot buy CDS for amounts higher than the face value of corporate bonds held by them and for periods longer than the tenor of corporate bonds held by them. They shall not, at any point of time, maintain naked CDS protection i.e. CDS purchase position without having an eligible underlying.
- Proper caveat has to be included in the agreement that the market-maker, while entering into and unwinding the CDS contract, needs to ensure that the user has exposure in the underlying.

  Further, the users are required to submit an auditor's certificate or custodian's certificate to the protection sellers or novating users (users transferring the CDS), of having the underlying bond while entering into/unwinding the CDS contract.
- Users cannot exit their bought positions by entering into an offsetting sale contract.

  They can exit their bought position by either unwinding the contract with the original counterparty or, in the event of sale of the underlying bond, by assigning (novating) the CDS protection, to the purchaser of the underlying bond (the "transferee") subject to consent of the original protection seller (the "remaining party").

  After assigning the contract, the original buyer of protection (the "transferor") will end his involvement in the transaction and credit risk will continue to lie with the original protection seller.
- In case of sale of the underlying, every effort should be made to unwind the CDS position immediately on sale of the underlying. The users are given a maximum grace period of ten business days from the date of sale of the underlying bond to unwind the CDS position.

- In the case of unwinding of the CDS contract, the original counterparty (protection seller) is required to ensure that the protection buyer has the underlying at the time of unwinding.

  The protection seller should also ensure that the transaction is done at a transparent market price and this must be subject to rigorous audit discipline.

- CDS transactions are not permitted to be entered into either between related parties or where the reference entity is a related party to either of the contracting parties.

  Related parties are as defined in 'Accounting Standard 18 – Related Party Disclosures'.

  In the case of foreign banks operating in India, the term 'related parties' includes an entity which is a related party of the foreign bank, its parent, or group entity.

- The user (except FIIs) and market-maker need to be resident entities.

- CDS Contracts

  - The identity of the parties responsible for determining whether a credit event has occurred must be clearly defined a priori in the documentation.
  - The reference asset/obligation and the deliverable asset/obligation should be to a resident and denominated in Indian Rupees.
  - The CDS contract has to be denominated and settled in Indian Rupees.
  - Obligations such as asset-backed securities/mortgage-backed securities, convertible bonds and bonds with call/put options are not permitted as reference and deliverable obligations.
  - CDS cannot be written on interest receivables.
  - CDS cannot be written on securities with original maturity up to one year e.g., Commercial Papers (CPs), Certificate of Deposits (CDs) and Non-Convertible Debentures (NCDs) with original maturity up to one year.
  - The CDS contract must represent a direct claim on the protection seller.
  - The CDS contract must be irrevocable; there must be no clause in the contract that would allow the protection seller to unilaterally cancel the contract. However, if protection buyer defaults under the terms of contract, protection seller can cancel/revoke the contract.
  - The CDS contract should not have any clause that may prevent the protection seller from making the credit event payment in a timely manner, after occurrence of the credit event and completion of necessary formalities in terms of the contract.
  - The protection seller shall have no recourse to the protection buyer for credit-event losses.

    - Dealing in any structured financial product with CDS as one of the components is not permitted.
    - Dealing in any derivative product where the CDS itself is an underlying is not permissible.
- The CDS contracts need to be standardized. The standardisation of CDS contracts in terms of coupon, coupon payment dates, etc. will be as put in place by FIMMDA in consultation with the market participants.
- The credit events specified in the CDS contract may cover: Bankruptcy, Failure to pay, Repudiation/moratorium, Obligation acceleration, Obligation default, Restructuring approved under Board for Industrial and Financial Reconstruction (BIFR) and Corporate Debt Restructuring (CDR) mechanism and corporate bond restructuring.

  The contracting parties to a CDS may include all or any of the approved credit events.

  Further, the definition of various credit events should be clearly defined in the bilateral Master Agreement.
- A Determination Committee (DC) formed by the market participants and FIMMDA has a key role. The DC, based in India, has to deliberate and resolve CDS related issues such as Credit Events, CDS Auctions, Succession Events, Substitute Reference Obligations, etc.

  At least 25 per cent of the members should be drawn from the users.

  The decisions of the Committee are binding on CDS market participants.
- The parties to the CDS transaction have to determine upfront, the procedure and method of settlement (cash/physical/auction) to be followed in the event of occurrence of a credit event and document the same in the CDS documentation.
    - For transactions involving users, physical settlement is mandatory.
    - For other transactions, market-makers can opt for any of the three settlement methods (physical, cash and auction), provided the CDS documentation envisages such settlement.
- While the physical settlement would require the protection buyer to transfer any of the deliverable obligations against the receipt of its full notional / face value, in cash settlement, the protection seller would pay to the protection buyer an amount equivalent to the loss resulting from the credit event of the reference entity.
- Auction settlement may be conducted in those cases as deemed fit by the DC. Auction specific terms (e.g. auction date, time, market quotation amount, deliverable obligations, etc.) will be set by the DC on a case by case basis.

If parties do not select Auction Settlement, they will need to bilaterally settle their trades in accordance with the Settlement Method (unless otherwise freshly negotiated between the parties).

- The accounting norms applicable to CDS contracts are on the lines indicated in the 'Accounting Standard AS-30 – Financial Instruments: Recognition and Measurement', 'AS – 31, Financial Instruments: Presentation' and 'AS-32 on Disclosures' as approved by the Institute of Chartered Accountants of India (ICAI).
- Market participants have to use FIMMDA published daily CDS curve to value their CDS positions. However, if a proprietary model results in a more conservative valuation, the market participant can use that proprietary model.
- For better transparency, market participants using their proprietary model for pricing in accounting statements have to disclose both the proprietary model price and the standard model price in notes to the accounts that should also include an explanation of the rationale behind using a particular model over another.
- The participants need to put in place robust risk management systems.
- Market-makers have to ensure adherence to suitability and appropriateness criteria while dealing with users.

  CDS transactions must be conducted in a transparent manner in relation to prices, market practices etc.

  From the protection buyer's side, it would be appropriate that the senior management is involved in transactions to ensure checks and balances. Protection sellers need to ensure:

  o CDS transactions are undertaken only on obtaining from the counterparty, a copy of a resolution passed by their Board of Directors, authorising the counterparty to transact in CDS.

  o The product terms are transparent and clearly explained to the counterparties along with risks involved.
- Market-makers have to report their CDS trades with both users and other market-makers on the reporting platform of the CDS trade repository within 30 minutes from the deal time.
- The users are required to affirm or reject their trade already reported by the market – maker by the end of the day.

In the event of sale of underlying bond by the user and the user assigning the CDS protection to the purchaser of the bond subject to the consent of the original protection seller, the original protection seller has to report such assignment to the trade reporting platform and the same should be confirmed by both the original user and the new assignee.

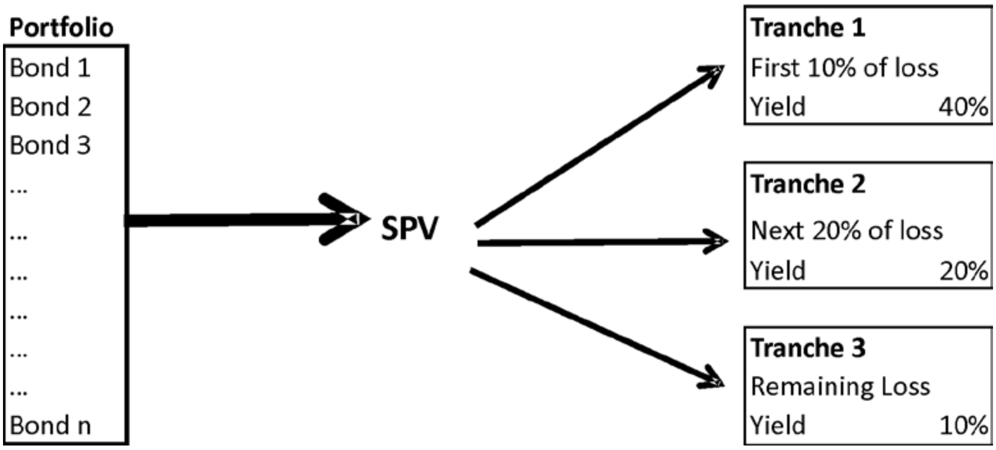
10.6 Collateralised Debt Obligation (CDO)

This is a structure, where a portfolio of bonds is transferred to a Special Purpose Vehicle (SPV).

The SPV splits the expected cash flows from the portfolio into various tranches, as shown in Figure 10.4

Figure 10.4

CDO Creation



Each tranche is sold to different classes of investors, based on their risk appetite.

- The first tranche will take 10% of the loss in the portfolio. Therefore, investors will in the normal course receive 40% return on their investment in the tranche. However, whenever there is a loss in the portfolio, it will first be charged to Tranche 1 (upto 10% of the portfolio).

  Suppose the portfolio loses 8%; suppose this amounts to 30% of Tranche 1. Then investors will lose 30% of their investment in Tranche 1. The yield of 40% will subsequently be given only on the balance 70% of their investment i.e. the yield will be down to 40% X 70% i.e. 28% of their original investment.

  In this manner, they will keep seeing erosion of their investment, upto portfolio loss of 10% in the SPV. If portfolio loss in the SPV hits 10%, the investors in Tranche 1 will lose their entire principal and not receive any further yield on their investment.

- Investors in the second tranche will book losses only if the portfolio loss in the SPV exceeds 10%. Thus, Tranche 2 is less risky than Tranche 1. Therefore, a lower yield of 20% is offered to investors in this Tranche.

  The excess of portfolio loss over 10% will keep getting written off against Tranche 2, until the total portfolio loss in the SPV touches 30% (10% for Tranche 1 + 20% for Trache 2).If portfolio loss in the SPV touches 30%, the investors in Tranche 2 will lose their entire principal and not receive any further yield.

- Investors in Tranche 3 have to book a loss only if portfolio loss in the SPV crosses 30%. In most prudent portfolios, this is a remote possibility. Therefore, the principal of investors in Tranche 3 is better protected. The yield offered to them is consequently lower at 10%.

Each tranche is given a separate credit rating. For instance, Tranche 3 may be AAA; Tranche 2 may be A; and Tranche 3 may be BBB.

Such CDO structures were a major cause for the global financial crisis in 2008. Lenders originated several loans of dubious quality and sold them off as CDOs. The credit quality of some of these tranches was enhanced by buying CDS from institutions that did not fully understand the risks involved. Credit Rating agencies too did not fully appreciate the portfolio risk and the risk of CDS-sellers defaulting.

When CDS-sellers defaulted, many 'AAA' rated tranches ended up in default. This shook the confidence of investors and lenders.

It is for this reason that investors need to fully comprehend the complex structures in which they invest, and not go blindly by the credit rating of the investment.

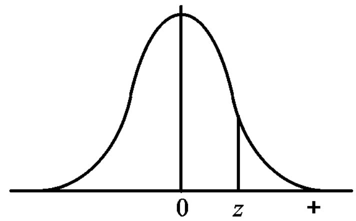
This also explains why the regulatory authorities in India are cautious in approving new product structures. It is widely recognised that such a cautious approach helped in protecting India from any direct fallout from the global financial crisis. As is inevitable in a globalised world, India did face, and continues to face, the indirect fallout of risk aversion, freezing of credit markets and recession in US and Europe.

Self-Assessment Questions

- Which of the following is good for the investor?
  - Higher default risk
  - **Higher recovery rate**
  - Both the above
  - None of the above
- A bond offers yield of 15%, when risk-free is at 8%. Recovery rate in the event of default is 25%. What is the default risk according to the market?
  - **9.33%**
  - 7%
  - 10.67%
  - 28%
- A company has issued 10% non-convertible debentures of face value Rs. 100 for 5 years. Subsequently, the continuously compounded yields have gone up to 11% for similar debentures and 7% for risk-free. What is the expected loss in the debentures as per the market?
  - Rs. 11.92
  - Rs. 4.89
  - Rs. 10.00
  - **Rs. 16.81**
- Which of the following does not help mitigate credit risk?
  - **Selling CDS**
  - Promoters' guarantee
  - Higher collateral
  - Structured obligation
- Which of the following is not permitted to be CDS market maker?
  - Standalone PD
  - Commercial Bank
  - **Manufacturing company**
  - NBFC

Annexure 1: Normal Distribution Table

NORMAL DISTRIBUTION TABLE



	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998

Annexure 2: Important Formulae

1. $s = \sqrt{\{1 \div (n-1) \times \sum \mu_t^2\} - \{1 \div n(n-1) \times (\sum \mu_t)^2\}}$

2. $\sigma_n^2 = \sum_{i=1}^{m} \propto_i \mu^2_{n-i}$

3. $\sigma_n^2 = \gamma V_L + \sum_{i=1}^{m} \propto_i \mu^2_{n-i}$

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

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

6. $C = S_0 N(d_1) - Ke^{-rT} N(d_2)$

7. $P = Ke^{-rT} N(-d_2) - S_0 N(-d_1)$

8. $C = S_0 e^{-qt} N(d_1) - Ke^{-rT} N(d_2)$

9. $P = Ke^{-rT} N(-d_2) - S_0 e^{-qt} N(-d_1)$

10. $\Theta = -\dfrac{S_0 N'(d_1)\sigma}{2\sqrt{T}} - rKe^{-rT} N(d_2)$

11. $\Theta = -\dfrac{S_0 N'(d_1)\sigma}{2\sqrt{T}} + rKe^{-rT} N(-d_2)$

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

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

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