

DERIVATIVES ANALYSIS AND VALUATION



LEARNING OUTCOMES

After going through the chapter student shall be able to understand

- ☐ Introduction to Forwards, Futures and Options
- ☐ Futures Market
- ☐ Pricing of Forwards and Futures
- ☐ Hedging using Futures
- ☐ Options
- ☐ Credit Derivatives
- ☐ Real Options
- ☐ Derivative Mishaps and Lessons
- ☐ Swaps
- ☐ Commodity Derivatives
- ☐ Weather Derivatives
- ☐ Electricity Derivatives



1. INTRODUCTION

Derivative is a product whose value is to be derived from the value of one or more basic variables called bases (underlying assets, index or reference rate). The underlying assets can be Equity, Forex, and Commodity.

The underlying has a marketable value which is subject to market risks. The importance of underlying in derivative instruments is as follows:

- ❖ All derivative instruments are dependent on an underlying to have value.
- ❖ The change in value in a forward contract is broadly equal to the change in value in the underlying.
- ❖ In the absence of a valuable underlying asset the derivative instrument will have no value.
- ❖ On maturity, the position of profit/loss is determined by the price of underlying instruments. If the price of the underlying is higher than the contract price the buyer makes a profit. If the price is lower, the buyer suffers a loss.

Main users of Derivatives are as follows:

	Users	Purpose
(a)	Corporation	To hedge currency risk and inventory risk.
(b)	Individual Investors	For speculation, hedging and yield enhancement.
(c)	Institutional Investor	For hedging asset allocation, yield enhancement and to avail arbitrage opportunities.
(d)	Dealers	For hedging position taking, exploiting inefficiencies and earning dealer spreads.

The basic differences between Cash and the Derivative market are enumerated below:-

- (a) In cash market, tangible assets are traded whereas in derivative market contracts based on tangible or intangibles assets like index or rates are traded.
- (b) In cash market, we can purchase even one share whereas in Futures and Options minimum lots are fixed.
- (c) Cash market is riskier than Futures and Options segment because in "Futures and Options" risk is limited upto 20%.
- (d) Cash assets may be meant for consumption or investment. Derivative contracts are for hedging, arbitrage or speculation.
- (e) The value of derivative contract is always based on and linked to the underlying security. However, this linkage may not be on point-to-point basis.

- (f) In the cash market, a customer must open securities trading account with a securities depository whereas to trade futures a customer must open a future trading account with a derivative broker.
- (g) Buying securities in cash market involves putting up all the money upfront whereas buying futures simply involves putting up the margin money.
- (h) With the purchase of shares of the company in cash market, the holder becomes part owner of the company. While in future it does not happen.

The most important derivatives are forward, futures and options.

2. FORWARD CONTRACT

Consider a Punjab farmer who grows wheat and has to sell it at a profit. The simplest and the traditional way for him is to harvest the crop in March or April and sell in the spot market then. However, in this way the farmer is exposing himself to risk of a downward movement in the price of wheat which may occur by the time the crop is ready for sale.

In order to avoid this risk, one way could be that the farmer may sell his crop at an agreed-upon rate now with a promise to deliver the asset, i.e., crop at a pre-determined date in future. This will at least ensure to the farmer the input cost and a reasonable profit.

Thus, the farmer would sell wheat forward to secure himself against a possible loss in future. It is true that by this way he is also foreclosing upon him the possibility of a bumper profit in the event of wheat prices going up steeply but then more important is that the farmer has played safe and insured himself against any eventuality of closing down his source of livelihood altogether. The transaction which the farmer has entered into is called a **forward transaction** and the contract which covers such a transaction is called a **forward contract**.

A forward contract is an agreement between a buyer and a seller obligating the seller to deliver a specified asset of specified quality and quantity to the buyer on a specified date at a specified place and the buyer, in turn, is obligated to pay to the seller a pre-negotiated price in exchange of the delivery.

This means that in a forward contract, the contracting parties negotiate on, not only the price at which the commodity is to be delivered on a future date but also on what quality and quantity to be delivered and at what place. No part of the contract is standardised and the two parties sit across each other and work out each and every detail of the contract before signing it.

For example, in case a gold bullion forward contract is being negotiated between two parties, they would negotiate each of the following features of the contract:

- ❖ the weight of the gold bullion to be delivered,
- ❖ the fineness of the metal to be delivered,

- ❖ the place at which the delivery is to be made,
- ❖ the period after which the delivery is to be made, and
- ❖ the price which the buyer would pay.

Suppose a buyer L and a seller S agrees to do a trade in 100 tolas of gold on 31 Dec 2013 at ₹ 30,000/tola. Here, ₹ 30,000/tola is the 'forward price of 31 Dec 2013 Gold'. The buyer L is said to be in long position and the seller S is said to be in short position. Once the contract has been entered into, L is obligated to pay S ₹ 30 lakhs on 31 Dec 2013, and take delivery of 100 tolas of gold. Similarly, S is obligated to be ready to accept ₹ 30 lakhs on 31 Dec 2013, and give 100 tolas of gold in exchange.



3. FUTURE CONTRACT

A Future Contract is an agreement between two parties that commits one party to buy an underlying financial instrument (bond, stock or currency) or commodity (gold, soyabean or natural gas) and one party to sell a financial instrument or commodity at a specific price at a future date. The agreement is completed at a specified expiration date by physical delivery or cash settlement or offset prior to the expiration date. In order to initiate a trade in futures contracts, the buyer and seller must put up "good faith money" in a margin account. Regulators, commodity exchanges and brokers doing business on commodity exchanges determine margin levels.

Suppose A buyer "B" and a Seller "S" enter into a 5,000 kgs Corn Futures contract at ₹ 5 per kg. Assuming that on the second day of trading the settlement price is ₹ 5.20 per kg. Settlement price is generally the representative price at which the contracts trade during the closing minutes of the trading period and this price is designated by a stock exchange as the settlement price. In case the price movement during the day is such that the price during the closing minutes is not the representative price, the stock exchange may select a price which it feels is close to being the representative price, e.g., average of the high and low prices which have occurred during a trading day. This price movement has led to a loss of ₹ 1,000 to S while B has gained the corresponding amount.

Thus, the initial margin account of S gets reduced by ₹ 1,000 and that of B is increased by the same amount. While the margin accounts, also called the equity of the buyer and the seller, get adjusted at the end of the day in keeping with the price movement, the futures contract gets replaced with a new one at a price which has been used to make adjustments to the buyer and seller's equity accounts. In this case, the settle price is ₹ 5.20, which is the new price at which next day's trading would start for this particular futures contract. Thus, each future contract is rolled over to the next day at a new price. This is called marking-to-market.

Difference between forward and future contract is as follows:

S. No.	Features	Forward	Futures
1.	Trading	Forward contracts are traded on personal basis or on telephone or otherwise.	Futures Contracts are traded in a competitive arena.
2.	Size of Contract	Forward contracts are individually tailored and have no standardized size	Futures contracts are standardized in terms of quantity or amount as the case may be
3.	Organized exchanges	Forward contracts are traded in an over-the-counter market.	Futures contracts are traded on organized exchanges with a designated physical location.
4.	Settlement	Forward contracts settlement takes place on the date agreed upon between the parties.	Futures contracts settlements are made daily via. Exchange's clearing house.
5.	Delivery date	Forward contracts may be delivered on the dates agreed upon and in terms of actual delivery.	Futures contracts delivery dates are fixed on cyclical basis and hardly takes place. However, it does not mean that there is no actual delivery.
6.	Transaction costs	Cost of forward contracts is based on bid – ask spread.	Futures contracts entail brokerage fees for buy and sell order.
7.	Marking to market	Forward contracts are not subject to marking to market	Futures contracts are subject to marking to market in which the loss or profit is debited or credited in the margin account on daily basis due to change in price.
8.	Margins	Margins are not required in forward contract.	In futures contracts every participants is subject to maintain margin as decided by the exchange authorities
9.	Credit risk	In forward contract, credit risk is born by each party and, therefore, every party has to bother for the creditworthiness.	In futures contract since the transaction is a two way transaction, the parties need not be bothered about the credit risk.



4. PRICING/ VALUATION OF FORWARD/ FUTURE CONTRACTS

The difference between the prevailing spot price of an asset and the futures price is known as the Basis, i.e.,

Basis = Spot price – Futures price

In a normal market, the spot price is less than the futures price (which includes the full cost-of-carry) and accordingly the basis would be negative. Such a market, in which the basis is decided solely by the cost-of-carry is known as a contango market.

Basis can become positive, i.e., the spot price can exceed the futures price only if there are factors other than the cost of carry to influence the futures price. In case this happens, then basis becomes positive and the market under such circumstances is termed as a backwardation market or inverted market.

Basis will approach zero towards the expiry of the contract, i.e., the spot and futures prices converge as the date of expiry of the contract approaches. The process of the basis approaching zero is called convergence.

The relationship between futures prices and cash prices is determined by the cost-of-carry. However, there might be factors other than cost-of-carry, especially in stock futures in which there may be various other returns like dividends, in addition to carrying costs, which may influence this relationship.

The cost-of-carry model in for futures/ forward, is as under:-

Future price = Spot price + Carrying cost – Returns (dividends, etc.)

This is also called as Theoretical minimum price or arbitrage free price as calculated above.

Let us take an example to understand this relationship.

Example

The price of ACC stock on 31 December 2010 was ₹ 220 and the futures price on the same stock on the same date, i.e., 31 December 2010 for March 2011 was ₹ 230. Other features of the contract and related information are as follows:

Time to expiration	- 3 months (0.25 year)
Borrowing rate	- 15% p.a.
Annual Dividend on the stock	- 25% payable before 31.03. 2011
Face Value of the Stock	- ₹ 10

Based on the above information, the futures price for ACC stock on 31 December 2010 should be:

$$= 220 + (220 \times 0.15 \times 0.25) - (0.25 \times 10) = 225.75$$

Thus, as per the 'cost of carry' criteria, the futures price is ₹ 225.75, which is less than the actual price of ₹ 230 on 31 March 2011. This would give rise to arbitrage opportunities and consequently the two prices will tend to converge.

How Will the Arbitrager Act?

He will buy the ACC stock at ₹ 220 by borrowing the amount @ 15 % for a period of 3 months and at the same time sell the March 2011 futures on ACC stock. By 31st March 2011, he will receive the dividend of ₹ 2.50 per share. On the expiry date of 31st March, he will deliver the ACC stock against the March futures contract sales.

The arbitrager's inflows/outflows are as follows:

Sale proceeds of March 2011 futures	₹ 230.00
Dividend	<u>₹ 2.50</u>
Total (A)	<u>₹ 232.50</u>
Pays back the Bank	₹ 220.00
Cost of borrowing	<u>₹ 8.25</u>
Total (B)	<u>₹ 228.25</u>
Balance (A) – (B)	₹ 4.25

Thus, the arbitrager earns ₹ 4.25 per share without involving any risk.

In financial forward contracts, the cost of carry is primarily the interest cost.

Let us take a very simple example of a fixed deposit in the bank. ₹ 100 deposited in the bank at a rate of interest of 10% would become ₹ 110 after one year. Based on annual compounding, the amount will become ₹ 121 after two years. Thus, we can say that the forward price of the fixed deposit of ₹ 100 is ₹ 110 after one year and ₹ 121 after two years.

As against the usual annual, semi-annual and quarterly compounding, which the reader is normally used to, continuous compounding are used in derivative securities. In terms of the annual compounding, the forward price can be computed through the following formula:

$$A = P (1+r/100)^t$$

Where, A is the terminal value of an amount P invested at a rate of interest of r % p.a. for t years.

However, in case there are multiple compounding in a year, say n times per annum, then the above formula will read as follows:

$$A = P (1+r/n)^{nt}$$

And in case the compounding becomes continuous, i.e., more than daily compounding, the above formula can be simplified mathematically and rewritten as follows:

$$A = Pe^{rt}$$

Where

e = Called epsilon, is a mathematical constant and has a value of - 2.718.

r = Risk-free Rate of Interest

t = Time Period

This function is available in all mathematical calculators and is easy to handle.

The above formula gives the future value of an amount invested in a particular security now. In this formula, we have assumed no interim income flow like dividends etc.

Example

Consider a 3-month maturity forward contract on a non-dividend paying stock. The stock is available for ₹ 200. With compounded continuously risk-free rate of interest (CCRRI) of 10 % per annum, the price of the forward contract would be:

$$A = 200 \times e^{(0.25)(0.10)} = ₹ 205.06$$

In case there is cash income accruing to the security like dividends, the above formula will read as follows:

$$A = (P - I)e^{rt}$$

Where I is the present value of the income flow during the tenure of the contract.

Example

Consider a 4-month forward contract on 500 shares with each share priced at ₹ 75. Dividend @ ₹ 2.50 per share is expected to accrue to the shares in a period of 3 months. The CCRRI is 10% p.a. The value of the forward contract is as follows:

$$\begin{aligned} \text{Dividend proceeds} &= 500 \times 2.50 = 1250 \\ &= 1250e^{-(3/12)(0.10)} = 1219.13 \\ \text{Value of forward contract} &= (500 \times 75 - 1219.13) e^{(4/12)(0.10)} \\ &= 36280.87 \times e^{0.033} \\ &= ₹ 37498.11 \end{aligned}$$

However, in case the income accretion to the securities is in the form of percentage yield, y , as in the case of stock indices arising on account of dividend accruals to individual stocks constituting the index, the above formula will read as follows:

$$A = Pe^{n(r - y)}$$

Correlation between Forward and Futures Prices

For contracts of the same maturity, the forward and futures contracts tend to have the same value subject to the interest rates remaining fixed. In case the interest rates are fluid, the value of a futures contract would differ from that of a forward contract because the cash flows generated from marking to the market in the case of the former would be available for reinvestment at variable rates on a

day-to-day basis. However, market imperfections like transaction costs, taxes and asset indivisibilities bring futures prices close enough to the forward prices and hence it is safe to assume that the two prices to be practically the same.



5. TYPES OF FUTURES CONTRACTS

5.1 Single Stock Futures

A single stock futures contract is an agreement to buy or sell shares or stock such as Microsoft, Intel, ITC, or Tata Steel at a point in the future. The buyer has an obligation to purchase shares or stock and the seller has an obligation to sell shares or stock at a specific price at a specific date in the future. Thus, a stock futures contract is a standardized contract to buy or sell a specific stock at a future date at an agreed price. Single-stock futures contracts are completed via offset or the delivery of actual shares at expiration. Margin on a single-stock futures contract is expected normally to be 20% of notional value.

Each Stock Future contract is standardized and includes basic specifications.

The terms of the contract call for delivery of the stock by the seller at some time specified in the future. However, most contracts are not held to expiration. The contracts are standardized, making them highly liquid. To get out of an open long (buying) position, the investor simply takes an offsetting short position (sells). Conversely, if an investor has sold (short) a contract and wishes to close it out, he or she buys (goes long) the offsetting contract.

5.2 Index Futures

A contract for stock index futures is based on the level of a particular stock index such as the S&P 500 or the Dow Jones Industrial Average or NIFTY or BSE Sensex. The agreement calls for the contract to be bought or sold at a designated time in the future based on the level of stock indexes. Just as hedgers and speculators buy and sell futures contracts based on future prices of individual stocks they may for the same reasons can buy and sell such contracts based on stock indexes.

Stock index futures may be used to either speculate on the equity market's general performance or to hedge a stock portfolio against a decline in value. Unlike commodity futures or individual stocks, stock index futures are not based on tangible goods, thus all settlements are in cash. Because settlements are in cash, investors usually have to meet liquidity or income requirements to show that they have money to cover their potential losses.

Stock index futures are traded in terms of number of contracts. Each contract is to buy or sell a fixed value of the index. The value of the index is defined as the value of the index multiplied by the specified monetary amount. In Nifty 50 futures contract traded at the National Stock Exchange, the contract specification states:

1 Contract = 50 units of Nifty 50 * Value of Nifty 50

If we assume that Nifty 50 is quoting at 8000, the value of one contract will be equal to ₹ 4,00,000 (50*8000). The contract size of 50 units of Nifty 50 in this case is fixed by National Stock Exchange where the contract is traded.

Example

Consider the following:

Current value of index	-	₹ 1400
Dividend yield	-	6% p.a.
CCRR	-	10% p.a.

To find the value of a 3 month forward contract.

$$A = P e^{t(r-y)}$$

$$= ₹ 1400 \times e^{(3/12)(0.10 - 0.06)} = ₹ 1400 \times 1.01005 = ₹ 1,414.07$$

5.2.1 Trading Mechanism in Stock Futures

While trading in futures contracts (both stock as well as futures) both buyers and sellers of the contract have to deposit an initial margin with their brokers based on the value of contract entered. The rules for calculation of margins to be deposited with the brokers are framed by the stock exchanges.

Another major feature regarding the margin requirements for stock as well index futures is that the margin requirement is continuous. Every business day, the broker will calculate the margin requirement for each position. The investor will be required to post additional margin funds if the account does not meet the minimum margin requirement.

The investor can square off his position in the futures contract before expiry or wait till expiry date when the contracts will automatically stand as squared off at the closing price on the expiry date. In Indian stock market the expiry date is the last Thursday of the relevant month to which the future contract belongs.

Example—Margin Requirements

In a stock future contract on ITC stock at ₹ 120, both the buyer and seller have a margin requirement of 20% or ₹ 24. If ITC stock goes up to ₹ 122, the account of the long contract is credited with ₹ 200 (₹ 122-₹ 120 = ₹ 2 X 100 = ₹ 200) and the account of the seller (seller) is debited by the same ₹ 200. This indicates that investors in futures must be very vigilant - they must keep close track of market movements.

5.2.2 Purpose of Trading in Futures

Trading in futures is for two purposes namely:

- (a) Speculation and
- (b) Hedging

(a) **Speculation** – For simplicity we will assume that one contract= 100 units and the margin requirement is 20% of the value of contract entered. Brokerage and transaction costs are not taken into account.

Example- Going Long on a Single Stock Futures Contract

Suppose an investor is bullish on McDonald's (MCD) and goes long on one September stock future contract on MCD at ₹ 80. At some point in the near future, MCD is trading at ₹ 96. At that point, the investor sells the contract at ₹ 96 to offset the open long position and makes a ₹ 1600 gross profit on the position.

This example seems simple, but let's examine the trades closely. The investor's initial margin requirement was only ₹ 1600 ($₹ 80 \times 100 = ₹ 8,000 \times 20\% = ₹ 1600$). This investor had a 100% return on the margin deposit. This dramatically illustrates the leverage power of trading futures. Of course, had the market moved in the opposite direction, the investor easily could have experienced losses in excess of the margin deposit.

The pay off table for the above transaction can be depicted as follows:-

Particulars	Details	Inflow/(outflow){In ₹}
Initial Payoff - Margin (Refundable at maturity)	₹ 8000 x 20% = ₹ 1600	(₹ 1600)
Pay off upon squaring off the contract	Profit (₹ 96 - ₹ 80) x 100 = ₹ 1600 Initial Margin = ₹ 1600	₹ 3200
Net Payoff		₹ 1600

Example- Going Short on a Single Stock Futures Contract

An investor is bearish in Kochi Refinery (KR) stock for the near future and goes short an August stock future contract on KR at ₹ 160. KR stock performs as the investor had guessed and drops to ₹ 140 in July. The investor offsets the short position by buying an August stock future at ₹ 140. This represents a gross profit of ₹ 20 per share, or a total of ₹ 2,000.

Again, let's examine the return the investor had on the initial deposit. The initial margin requirement was ₹ 3,200 ($₹ 160 \times 100 = ₹ 16,000 \times 20\% = ₹ 3,200$) and the gross profit was ₹ 2,000. The return on the investor's deposit was more than 60% - a terrific return on a short-term investment.

Particulars	Details	Inflow/(outflow){In ₹}
Initial Payoff - Margin (Refundable at maturity)	₹ 160 x 100 x 20% = ₹ 3200	(₹ 3200)
Pay off upon squaring off the contract	Profit (₹ 160 - ₹ 140) x 100 = ₹ 2000 Initial Margin = ₹ 3200	₹ 5200
Net Payoff		₹ 2000

Example- Going Long on an Index Futures Contract

Suppose an investor has a bullish outlook for Indian market for the month of October 2014. He will go for a long position in October 2014 Nifty Index Future Contract. Assuming that he enters into long positions when Nifty is trading at 8000 and one month later, he squares off his position when the value of Nifty rises to 8500 his payoff will be as under. (Assuming that one contract= 50 units of Nifty and margin requirement is 20% of the value of the contract)

Particulars	Details	Inflow/(outflow){In ₹}
Initial Payoff - Margin (Refundable at maturity)	$(8000 \times 50 \times 20\%) = ₹ 80,000$	(₹ 80,000)
Pay off upon squaring off the contract	Profit $(8500 - 8000) \times 50 = ₹ 25,000$ Initial Margin = ₹ 80,000	₹ 1,05,000
Net Payoff		₹ 25,000

Example- Going Short on an Index Futures Contract

Suppose an investor has a bearish outlook for Indian banking sector for the month of October 2014. He will go for a short position for one October 2014 Bank Nifty Future Contract. Assuming that he enters into short positions when Bank Nifty is trading at 25000 and one month later he squares off his position when the value of Bank Nifty declines to 24000 his payoff will be as under. (Assuming that one contract = 10 units of Bank Nifty and margin requirement is 20% of the value of the contract)

Particulars	Details	Inflow/(outflow){In ₹}
Initial Payoff - Margin (Refundable at maturity)	$(25000 \times 10 \times 20\%) = ₹ 50,000$	(₹ 50,000)
Pay off upon squaring off the contract	Profit $(25000 - 24000) \times 10 = ₹ 10,000$ Initial Margin = ₹ 50,000	₹ 60,000
Net Payoff		₹ 10,000

(b) Hedging – Hedging is the practice of taking a position in one market to offset and balance against the risk adopted by assuming a position in a contrary or opposing market or investment. In simple language, hedging is used to reduce any substantial losses/gains suffered by an individual or an organization. To hedge, the investor takes a stock future position exactly opposite to the stock position. That way, any losses on the stock position will be offset by gains on the future position.

Example- Using single stock future as a Hedge

Consider an investor who has bought 100 shares of Tata Steel (TS) at ₹ 300. In July, the stock is trading at ₹ 350. The investor is happy with the unrealized gain of ₹ 50 per share but is concerned that in a stock as volatile as TS, the gain could be wiped out in one bad day. The investor wishes to keep the stock at least until September, however, because of an upcoming dividend payment.

To hedge, the investor sells a ₹ 350 September stock future contract - whether the stock rises or declines, the investor has locked in the ₹ 50-per-share gain. In September on maturity date of the

futures contract (last Thursday of September) , the investor sells the stock at the market price and buys back the future contract.

The pay-off at various price levels of Tata Steel is as under:-

Particulars	September Closing price of Tata Steel= ₹ 300	September Closing price of Tata Steel= ₹ 350	September Closing price of Tata Steel= ₹ 400
<i>Initial Payoff</i>			
Cost of scrip in cash market	₹ 300 x 100 = ₹ 30000	₹ 300 x 100 = ₹ 30000	₹ 300 x 100 = ₹ 30000
Margin Payment on futures contract	₹ 350 x 100 x 20% = ₹ 7000	₹ 350 x 100 x 20% = ₹ 7000	₹ 350 x 100 x 20% = ₹ 7000
Total Initial Payoff (outflow)	₹ 37000	₹ 37000	₹ 37000
<i>Pay-off at maturity (September end)</i>			
	Sale proceeds of TS in cash market= ₹ 300 x 100 = ₹ 30000	Sale proceeds of TS in cash market= ₹ 350 x 100 = ₹ 35000	Sale proceeds of TS in cash market= ₹ 400 x 100 = ₹ 40000
	Margin refund on futures contract = ₹ 7000	Margin refund on futures contract = ₹ 7000	Margin refund on futures contract = ₹ 7000
	Gain on futures contract (inflow) = (₹ 350 - ₹ 300) x 100 = ₹ 5000	No profit /loss on futures contract = (₹ 350 - ₹ 350) x 100 = ₹ 0	Loss on futures contract (outflow) = (₹ 350 - ₹ 400) x 100 = - ₹ 5000
Total Pay-off at maturity (Inflow)	₹ 42000	₹ 42000	₹ 42000
Net Payoff	₹ 5000	₹ 5000	₹ 5000

Hence, it can be observed in the above table that in any case the investor has locked in a profit of ₹ 5000 via hedging.

In a similar manner as illustrated above index futures can also be used as a hedge. The difference would be that instead of single stock futures the investor would enter into a position into an Index Futures Contract according to the risk potential of the investor. Index Futures are also used to hedge a Portfolio of shares and number of contracts depends upon the β of the portfolio.

5.2.3 Marking to Market

It implies the process of recording the investments in traded securities (shares, debt-instruments, etc.) at a value, which reflects the market value of securities on the reporting date. In the context of derivatives trading, the futures contracts are marked to market on periodic (or daily) basis. Marking

to market essentially means that at the end of a trading session, all outstanding contracts are repriced at the settlement price of that session. Unlike the forward contracts, the future contracts are repriced every day. Any loss or profit resulting from repricing would be debited or credited to the margin account of the broker. It, therefore, provides an opportunity to calculate the extent of liability on the basis of repricing. Thus, the futures contracts provide better risk management measure as compared to forward contracts.

Suppose on 1st day we take a long position, say at a price of ₹ 100 to be matured on 7th day. Now on 2nd day if the price goes up to ₹ 105, the contract will be repriced at ₹ 105 at the end of the trading session and profit of ₹ 5 will be credited to the account of the buyer. This profit of ₹ 5 may be drawn and thus cash flow also increases. This marking to market will result in three things – one, you will get a cash profit of ₹ 5; second, the existing contract at a price of ₹ 100 would stand cancelled; and third you will receive a new futures contract at ₹ 105. In essence, the marking to market feature implies that the value of the futures contract is set to zero at the end of each trading day.

5.2.4 Advantages of Stock Index Futures Trading Vs. Stock Futures Trading

Stock index futures is most popular financial derivatives over stock futures due to following reasons:

1. It adds flexibility to one's investment portfolio. Institutional investors and other large equity holders prefer this instrument the most in terms of portfolio hedging purpose. The stock systems do not provide this flexibility and hedging.
2. It creates the possibility of speculative gains using leverage. Because a relatively small amount of margin money controls a large amount of capital represented in a stock index contract, a small change in the index level might produce a profitable return on one's investment if one is right about the direction of the market. Speculative gains in stock futures are limited but liabilities are greater.
3. Stock index futures are the most cost-efficient hedging device whereas hedging through individual stock futures is costlier.
4. Stock index futures cannot be easily manipulated whereas individual stock price can be exploited more easily.
5. Since, stock index futures consists of many securities, so being an average stock, is much less volatile than individual stock price. Further, it implies much lower capital adequacy and margin requirements in comparison of individual stock futures. Risk diversification is possible under stock index future than in stock futures.
6. One can sell contracts as readily as one buys them and the amount of margin required is the same.
7. In case of individual stocks the outstanding positions are settled normally against physical delivery of shares. In case of stock index futures they are settled in cash all over the world on the premise that index value is safely accepted as the settlement price.

8. It is also seen that regulatory complexity is much less in the case of stock index futures in comparison to stock futures.
9. It provides hedging or insurance protection for a stock portfolio in a falling market.

5.2.5 Uses/Advantages of Stock Index Futures

Investors can use stock index futures to perform myriad tasks. Some common uses are:

- (1) Investors commonly use stock index futures to change the weightings or risk exposures of their investment portfolios. A good example of this is investors who hold equities from two or more countries. Suppose these investors have portfolios invested in 60 percent U.S. equities and 40 percent Japanese equities and want to increase their systematic risk to the U.S. market and reduce these risks to the Japanese market. They can do this by buying U.S. stock index futures contracts in the indexes underlying their holdings and selling Japanese contracts (in the Nikkei Index).
- (2) Stock index futures also allow investors to separate market timing from market selection decisions. For instance, investors may want to take advantage of perceived immediate increases in an equity market but are not certain which securities to buy; they can do this by purchasing stock index futures. If the futures contracts are bought and the present value of the money used to buy them is invested in risk-free securities, investors will have a risk exposure equal to that of the market. Similarly, investors can adjust their portfolio holdings at a more leisurely pace. For example, assume the investors see that they have several undesirable stocks but do not know what holdings to buy to replace them. They can sell the unwanted stocks and, at the same time, buy stock index futures to keep their exposure to the market. They can later sell the futures contracts when they have decided which specific stocks they want to purchase.
- (3) Investors can also make money from stock index futures through index arbitrage, also referred to as program trading as it is carried out through use of computers. Basically, arbitrage is the purchase of a security or commodity in one market and the simultaneous sale of an equal product in another market to profit from pricing differences. Investors taking part in stock index arbitrage seek to gain profits whenever a futures contract is trading out of line with the fair price of the securities underlying it. Thus, if a stock index futures contract is trading above its fair value, investors could buy a basket of stocks composing the index in the correct proportion—such as a mutual fund comprised of stocks represented in the index—and then sell the expensively priced futures contract. Once the contract expires, the equities could then be sold and a net profit would result. While the investors can keep their arbitrage position until the futures contract expires, they are not required to. If the futures contract seems to be returning to fair market value before the expiration date, it may be prudent for the investors to sell early.
- (4) Investors often use stock index futures to hedge the value of their portfolios. Provide hedging or insurance protection for a stock portfolio in a falling market. To implement a hedge, the instruments in the cash and futures markets should have similar price movements. Also, the

amount of money invested in the cash and futures markets should be the same. To illustrate, while investors owning well-diversified investment portfolios are generally shielded from unsystematic risk (risk specific to particular firms), they are fully exposed to systematic risk (risk relating to overall market fluctuations). A cost-effective way for investors to reduce the exposure to systematic risk is to hedge with stock index futures, similar to the way that people hedge commodity holdings using commodity futures. Investors often use short hedges when they are in a long position in a stock portfolio and believe that there will be a temporary downturn in the overall stock market. Hedging transfers the price risk of owning the stock from a person unwilling to accept systematic risks to someone willing to take the risk.

To carry out a short hedge, the hedger sells a futures contract; thus, the short hedge is also called a "sell-hedge."

Example

Consider investors who own portfolios of securities valued at \$1.2 million with a dividend of 1 percent. The investors have been very successful with their stock picks. Therefore, while their portfolios' returns move up and down with the market, they consistently outperform the market by 6 percent. Thus, the portfolio would have a beta of 1.00 and an alpha of 6 percent. Say that the investors believe that the market is going to have a 15 percent decline, which would be offset by the 1 percent received from dividends. The net broad market return would be -14 percent but, since they consistently outperform the market by 6 percent, their estimated return would be -8 percent. In this instance, the investors would like to cut their beta in half without necessarily cutting their alpha in half. They can achieve this by selling stock index futures. In this scenario, the S&P 500 index is at 240. The contract multiplier is \$500, and therefore each contract represents a value of \$120,000. Since the investors want to simulate the sale of half of their \$1.2 million portfolios, they must sell five contracts ($5 \times \$120,000 = \$600,000$). Thus, their portfolios would be affected by only half of the market fluctuation. While the investors could protect their portfolios equally well by selling half of their shares of stock and buying them again at short time later, using a short hedge on stock index futures is much cheaper than paying the capital gains tax plus the broker commissions associated with buying and selling huge blocks of stock.

At the extreme, stock index futures can theoretically eliminate the effects of the broad market on a portfolio. Perfect hedges are very unusual because of the existence of basis risk. The basis is the difference between the existing price in the futures market and the cash price of the underlying securities. Basis risk occurs when changes in the economy and the financial situation have different impacts on the cash and futures markets.

- (5) Stock index futures add flexibility to his or her portfolio as a hedging and trading instrument.
- (6) Create the possibility of speculative gains using leverage. Because a relatively small amount of margin money controls a large amount of capital represented in a stock index contract, a small change in the index level might produce a profitable return on one's investment if he or she is right about the market's direction.

- (7) Maintain one's stock portfolio during stock market corrections. One may not need "insurance" for all the time, but there are certain times when one would like less exposure to stocks. Yet, one doesn't want to sell off part of a stock portfolio that has taken him or her a long time to put together and looks like a sound, long-term investment program.
- (8) One of the major advantages of futures markets, in general, is that one can sell contracts as readily as he or she can buy them and the amount of margin required is the same. Mutual funds do not specialize in bear market approaches by short selling stocks but, and also it is not possible for individuals to short sell stocks in a falling market to make money.
- (9) Transfer risk quickly and efficiently. Whether one is speculating, looking for insurance protection (hedging), or temporarily substituting futures for a later cash transaction, most stock index futures trades can be accomplished quickly and efficiently. Many mutual funds require investors to wait until the end of the day to see at what price they were able to purchase or sell shares. With today's volatility, once-a-day pricing may not give one the maneuverability to take positions at exactly the time he or she wants. Stock index futures give individual the opportunity to get into or out of a position whenever he or she wants.



6. OPTIONS

An Option may be understood as a privilege, sold by one party to another, that gives the buyer the right, but not the obligation, to buy (call) or sell (put) any underlying say stock, foreign exchange, commodity, index, interest rate etc. at an agreed-upon price within a certain period or on a specific date regardless of changes in underlying's market price during that period.

The various kinds of stock options include put and call options, which may be purchased in anticipation of changes in stock prices, as a means of speculation or hedging. A put gives its holder an option to sell, shares to another party at a fixed price even if the market price declines. A call gives the holder an option to buy, or call for, shares at a fixed price even if the market price rises.

6.1 Stock Options

Stock options involve no commitments on the part of the buyers of the option contracts to purchase or sell the stock. The option is usually exercised only if the price of the stock has risen above (in case of call option) or fallen below (in case of put option) the price specified at the time the option was given. One important difference between stocks and options is that stocks give you a small piece of ownership in the company, while options are just contracts that give you the right to buy or sell the stock at a specific price by a specific date. Investing in options provide limited risk, high potential reward and smaller amount of capital required to control the same number of shares which can be done via investing through cash market.

6.2 Stock Index Option

It is a call or put option on a financial index. Investors trading index options are essentially betting on the overall movement of the stock market as represented by a basket of stocks.

Index options can be used by the portfolio managers to limit their downside risk. Suppose the value of the index is S . Consider a manager in charge of a well diversified portfolio which has a β of 1.0 so that its value mirrors the value of the index. If for each 100 S rupees in the portfolio, the manager buys one put option contract with exercise price X , the value of the portfolio is protected against the possibility of the index falling below X . For instance, suppose that the manager's portfolio is worth ₹ 10,00,000 and the value of the index is 10000. The portfolio is worth 100 times the index. The manager can obtain insurance against the value of the portfolio dropping below ₹ 900,000 in the next two months by buying 1 put option contracts with a strike price of ₹ 9000. To illustrate how this would work, consider the situation where the index drops to 8500. The portfolio will be worth ₹ 850000 (100×8500). However, the payoff from the options will be $1 \times (\text{₹ } 9000 - \text{₹ } 8500) \times 100 = \text{₹ } 50000$, bringing the total value of the portfolio up to the insured value of ₹ 9,00,000.

6.3 Parties to the Options

There are always two types of entities for an option transaction viz buyer and a seller (also known as writer of the option). So, for every call or put option purchased, there is always someone else selling/buying it. When individuals sell options, they effectively create a security that didn't exist before. This is known as writing an option and explains one of the main sources of options, since neither the associated company nor the options exchange issues options. When you write a call, you may be obligated to sell shares at the strike price any time before the expiration date. When you write a put, you may be obligated to buy shares at the strike price any time before expiration. The price of an option is called its premium. The buyer of an option cannot lose more than the initial premium paid for the contract, no matter what happens to the underlying security. So, the risk to the buyer is never more than the amount paid for the option. The profit potential, on the other hand, is theoretically unlimited

6.4 Premium for Options

In return for the premium received from the buyer, the seller of an option assumes the risk of having to deliver (if a call option) or taking delivery (if a put option) of the shares of the stock. Unless that option is covered by another option or a position in the underlying stock (opposite to the position taken via selling the option contracts), the seller's loss can be unlimited, meaning the seller can lose much more than the original premium received.

6.5 Types of Options

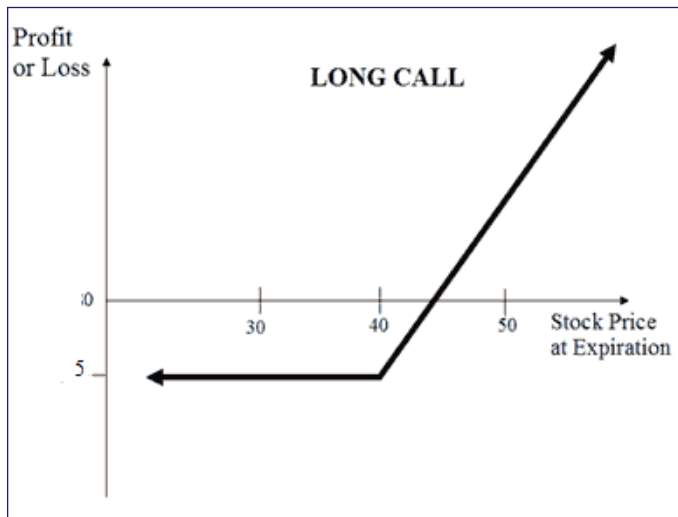
You should be aware that there are two basic styles of options: American and European. An American, or American-style, option can be exercised at any time between the date of purchase and the expiration date. Most exchange-traded options are American style and all stock options are American style. A European, or European-style, option can only be exercised on the expiration date. In Indian Market most of the options are European style options.

6.6 Pay-off scenarios

The possible pay-off under various scenarios are as follows:

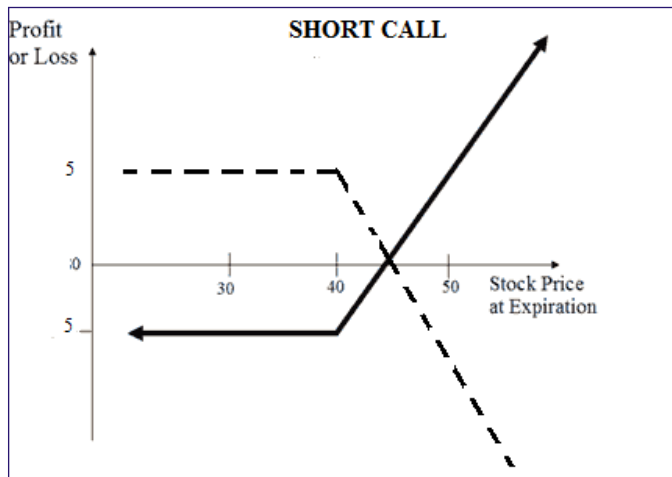
6.6.1 Pay-off for a Call Buyer

Also, called Long Call. For example, Mr. X buys a call option at strike price of ₹ 40 in exchange of a premium of ₹ 5. In case if actual price of the stock at the time of exercise is less than ₹ 40, Mr. X would not exercise his option and his loss would be ₹ 5. Mr. X would exercise his option at any price above ₹ 40. In such a situation his loss would start reducing and at the price of ₹ 45 there will be Break Even.



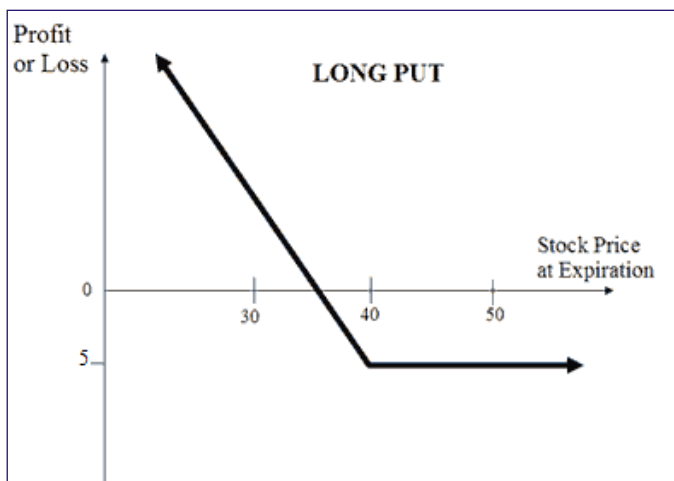
6.6.2 Pay-off for a Call Seller

Also, called Short Call. The pay-off profile of Call Seller shall be the mirror image of the Long Call as shown below in dotted line.



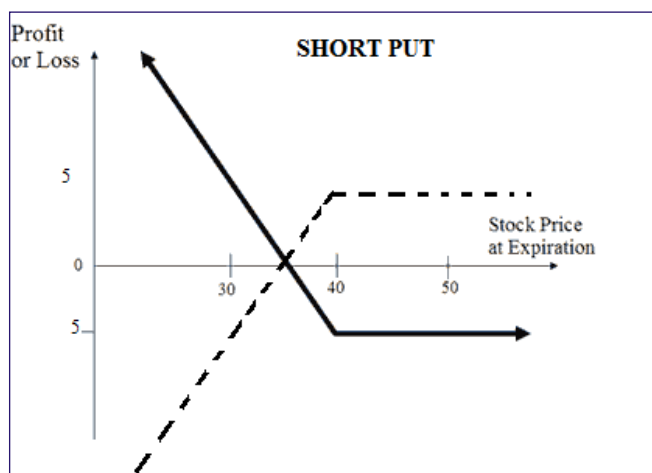
6.6.3 Pay-off for a Put Buyer

Also, called Long Put. For example, Mr. X buys a put option at strike price of ₹ 40 in exchange of a premium of ₹ 5. In case if actual price of the stock at the time of exercise is less than ₹ 40, Mr. X would exercise his option and his gain would be (Spot Price – Exercise Price – Premium). Mr. X would exercise his option at any price below ₹ 40. The break-even price will be ₹ 35 and Mr. X would not exercise his option for any price above ₹ 40.



6.6.4 Pay-off for a Put Seller

Also, called Short Put. The pay-off profile of Put Seller shall be the mirror image of the Long Put as shown below in dotted line.



6.7 Comparison with Single Stock Futures

Investing in stock futures differs from investing in equity options contracts in several ways:

- *Nature:* In options, the buyer of the options has the right but not the obligation to purchase or

sell the stock. However while going in for a long futures position, the investor is obligated to square off his position at or before the expiry date of the futures contract.

- *Movement of the Market:* Options traders use a mathematical factor, the delta that measures the relationship between the options premium and the price of the underlying stock. At times, an option contract's value may fluctuate independently of the stock price. In contrast, the future contract will much more closely follow the movement of the underlying stock.
- *The Price of Investing:* When an options investor takes a long position, he or she pays a premium for the contract. The premium is often called a sunk cost. At expiration, unless the options contract is in the money, the contract is worthless and the investor has lost the entire premium. Stock future contracts require an initial margin deposit and a specific maintenance level of cash for mark to market margin

7. OPTION VALUATION TECHNIQUES

We have already been introduced to characteristics of both European and American Options. Assuming a European Call Option on a non-dividend paying stock, it is easy to see that its value at expiration date shall either be zero or the difference between the market price and the exercise price, whichever is higher. It may be noted that the value of an Option cannot be negative. An investor is required to pay a premium for acquiring such an Option. In case this premium is less than the value of the Option, the investor shall make profits, however, in case the premium paid is more than the value, the investor shall end up losing money. Note that, while measuring these gains or losses, Time Value of Money and Transaction Costs have been ignored. The opposite picture emerges for the Writer.

The Value of an Option with one period to expire: Simply speaking, the theoretical value of an Option should be the difference between the current stock price and the exercise price. In case the stock price is less than the exercise price the theoretical value shall be zero. However, as long as there is time to expiration it is possible for a zero theoretical value Option to have some actual positive Market value. This is because there may be a possibility of the stock price rising at which point of time the Option may be exercised advantageously.

7.1 Binomial Model

The binomial model breaks down the time to expiration into potentially a very large number of time intervals, or steps. This requires the use of probability and future discrete projections through which a tree of stock prices is initially produced working forward from the present to expiration.

To facilitate understanding we shall restrict ourselves to a European Option having a one year time branching process where at the end of the year there are only two possible values for the common stock. One is higher and the other lower than the current value. Assume that the probability of the two values to materialize is known. In such a situation, a hedged position can be established by buying the stock and by writing Options. This shall help offset price movements. At each step, it is

assumed that the stock price will either move up or down. The pricing of the Options should be such that the return equals the risk-free rate.

The above mentioned is an example of Binomial Distribution. When the number of high and low value projections for the concerned stock are numerous, the tree shall represent all possible paths that the stock price could take during the life of the option.

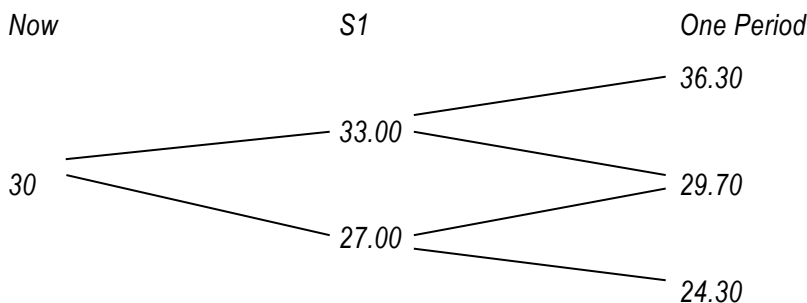
At the end of the tree - i.e. at expiration of the option - all the terminal option prices for each of the final possible stock prices are known as they simply equal their intrinsic values.

The big advantage the binomial model has over the Black-Scholes model is that it can be used to accurately price American options. This is because with the binomial model it's possible to check at every point in an option's life (i.e. at every step of the binomial tree) for the possibility of early exercise (e.g. a put option being deeply in the money and due to dividend declaration its price at that point is less than its intrinsic value).

Where an early exercise point is found it is assumed that the option holder would elect to exercise, and the option price can be adjusted to equal the intrinsic value at that point. This then flows into the calculations higher up the tree and so on.

Illustration 1

Following is a two sub-periods tree of 6-months each for the share of CAB Ltd.:



Using the binomial model, calculate the current fair value of a regular call option on CAB Stock with the following characteristics: $X = ₹ 28$, Risk Free Rate = 5 percent p.a. You should also indicate the composition of the implied riskless hedge portfolio at the valuation date.

Solution

$$u = 33.00/30.00 = 36.30/33.00 = 1.10 \quad d = 27.00/30.00 = 24.30/27.00 = 0.90$$

$$r = (1 + .05)^{1/2} = 1.0247$$

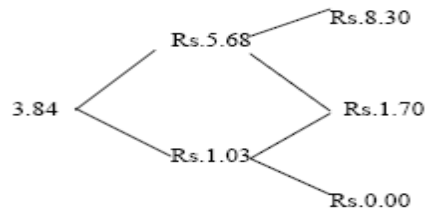
$$p = \frac{r - d}{u - d} = \frac{1.0247 - 0.90}{1.10 - 0.90} = 0.1247/0.20 = 0.6235 \text{ (Prob. of increase in Price of Share)}$$

$$\text{Prob. of decrease in Price of Share} = 1 - 0.6235 = 0.3765$$

$$C_{uu} = \text{Max} [0, 36.30 - 28] = 8.30$$

$$C_{ud} = \text{Max} [0, 29.70 - 28] = 1.70$$

$$C_{dd} = \text{Max} [0, 24.30 - 28] = 0$$



$$C_u = \frac{(0.6235)(8.30) + (0.3765)(1.70)}{1.025} = \frac{5.175 + 0.640}{1.025} = 5.815/1.025 = ₹ 5.673$$

$$C_d = \frac{(0.6235)(1.70) + (0.3765)(0.00)}{1.025} = \frac{1.05995}{1.025} = ₹ 1.0341$$

$$C_o = \frac{(0.6235)(5.673) + (0.3765)(1.0341)}{1.025} = \frac{3.537 + 0.3893}{1.025} = ₹ 3.83$$

The composition of the implied risk-less hedge portfolio at valuation date is called Delta (Δ) and it is calculated as follows:

$$\frac{C_u - C_d}{S_u - S_d}$$

Where,

C_u = Pay-off from Call Option if price of Stock goes up

C_d = Pay-off from Call Option if price of Stock goes down

S_u = Upward price of the Stock

S_d = Downward price of the Stock

Accordingly, the Risk-less Portfolio shall require Δ Share shall be required for writing off one Call Option. The Δ shall be computed as follows:

$$\Delta = \frac{5 - 0}{33 - 27} = \frac{5}{6}$$

Thus, $\frac{5}{6}$ shares shall be held or purchased for writing one Call Option.

7.2 Risk Neutral Method

The “risk-neutral” technique can also be used to value derivative securities. It was developed by John Cox and Stephen Ross in 1976. The basic argument in the risk neutral approach is that since the valuation of options is based on arbitrage and is therefore independent of risk preferences; one should be able to value options assuming any set of risk preferences and get the same answer as by using Binomial Model. This model is a simple model.

Using this model, we can derive the risk neutral probabilities and apply the same probabilities in the binomial model.

Example

Suppose the price of the share of Company X is ₹ 50. In one year, it is expected either to go up to ₹ 60 or go down to ₹ 40. The risk-free rate of interest is 5%.

Let p be the probability that the price will increase then $(1-p)$ will be probability of price decrease. The value of the stock today must be equal to the present value of the expected price after one year discounted at risk-free rate as follows:

$$50 = \frac{60p + 40(1-p)}{1.05}$$

On solving we shall get the value of $p = 0.625$. With this value we can find out the present value of the expected payout as follows:

$$\frac{10(0.625) + 0(1 - 0.625)}{1.05} = 5.95$$

It may however be noted that the discounting can also be made on daily basis as shown in following illustration.

Illustration 2

The current market price of an equity share of Penchant Ltd is ₹ 420. Within a period of 3 months, the maximum and minimum price of it is expected to be ₹ 500 and ₹ 400 respectively. If the risk free rate of interest be 8% p.a., what should be the value of a 3 months Call option under the “Risk Neutral” method at the strike rate of ₹ 450 ? Given $e^{0.02} = 1.0202$

Solution

Let the probability of attaining the maximum price be p

$$(500 - 420) \times p + (400 - 420) \times (1-p) = 420 \times (e^{0.02} - 1)$$

$$\text{or, } 80p - 20(1 - p) = 420 \times 0.0202$$

$$\text{or, } 80p - 20 + 20p = 8.48$$

$$\text{or, } 100p = 28.48$$

$$p = 0.2848$$

$$\text{The value of Call Option in ₹} = \frac{0.2848 \times (500 - 450)}{1.0202} = \frac{0.2848 \times 50}{1.0202} = 13.96$$

7.3 Black-Scholes Model

The Black-Scholes model is used to calculate a theoretical price of an Option. The Black-Scholes price is nothing more than the amount an option writer would require as compensation for writing a call and completely hedging the risk of buying stock. The important point is that the hedger's view about future stock prices is irrelevant. Thus, while any two investors may strongly disagree on the rate of return they expect on a stock they will, given agreement to the assumptions of volatility and the risk-free rate, always agree on the fair value of the option on that underlying asset. This key concept underlying the valuation of all derivatives -- that fact that the price of an option is independent of the risk preferences of investors -- is called risk-neutral valuation. It means that all derivatives can be valued by assuming that the return from their underlying assets is the risk-free rate.

The model is based on a normal distribution of underlying asset returns.

The following assumptions accompany the model:

1. European Options are considered,
2. No transaction costs,
3. Short term interest rates are known and are constant,
4. Stocks do not pay dividend,
5. Stock price movement is similar to a random walk,
6. Stock returns are normally distributed over a period of time, and
7. The variance of the return is constant over the life of an Option.

The original formula for calculating the theoretical option price (OP) is as follows:

$$OP = SN(d_1) - Xe^{-rt}N(d_2)$$

Where:

$$d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left(r + \frac{v^2}{2}\right)t}{v\sqrt{t}}$$

$$d_2 = d_1 - v\sqrt{t}$$

The variables are:

- S = current stock price
X = strike price of the option

- t = time remaining until expiration, expressed as a percent of a year
 r = current continuously compounded risk-free interest rate
 v = annual volatility of stock price (the standard deviation of the short-term returns over one year).
 \ln = natural logarithm
 $N(x)$ = standard normal cumulative distribution function (Area under Normal Curve)
 e = the exponential function

Understanding the formula

$N(d_1)$ represents the hedge ratio of shares of stock to Options necessary to maintain a fully hedged position.

Consider the Option holder as an investor who has borrowed an equivalent amount of the exercise price at interest rate r . $Xe^{-rt}N(d_2)$ represents this borrowing which is equivalent to the present value of the exercise price times an adjustment factor of $N(d_2)$

$N(d_2)$ in the above formulae represents the probability that price in spot market on expiration would be higher than the exercise price of the call option.

The main advantage of the Black-Scholes model is speed -- it lets you calculate a very large number of option prices in a very short time.

The Black-Scholes model has one major limitation that it cannot be used to accurately price options with an American-style exercise as it only calculates the option price at one point of time -- at expiration. It does not consider the steps along the way where there could be the possibility of early exercise of an American option.

Illustration 3

- (i) The shares of TIC Ltd. are currently priced at ₹ 415 and call option exercisable in three months' time has an exercise rate of ₹ 400. Risk free interest rate is 5% p.a. and standard deviation (volatility) of share price is 22%. Based on the assumption that TIC Ltd. is not going to declare any dividend over the next three months, is the option worth buying for ₹ 25?
- (ii) Calculate value of aforesaid call option based on Black Scholes valuation model if the current price is considered as ₹ 380.
- (iii) What would be the worth of put option if current price is considered ₹ 380.
- (iv) If TIC Ltd. share price at present is taken as ₹ 408 and a dividend of ₹ 10 is expected to be paid in the two months time, then, calculate value of the call option.

Given

$$\ln(1.0375) = 0.03681$$

$$\ln(0.95) = -0.05129$$

$$\ln(0.9952) = -0.00481$$

$$e^{0.0125} = 1.012578$$

$$e^{0.008333} = 1.0084$$

Solution

(i) Given: TIC Ltd. Current Price = ₹ 415

Exercise rate = 400

Risk free interest rate is = 5% p.a.

SD (Volatility) = 22%

Based on the above bit is calculated value of an option based on Black Scholes Model:

$$d_1 = \frac{\ln\left(\frac{415}{400}\right) + \left[.05 + \frac{1}{2} (22)^2\right] .25}{.22 \sqrt{.25}}$$

$$= \frac{.03681 + .01855}{.11} = .5032727$$

$$d_2 = \frac{\ln\left(\frac{415}{400}\right) + \left[.05 - \frac{1}{2} (22)^2\right] .25}{.22 \sqrt{.25}}$$

$$= \frac{.03681 + .00645}{.11} = 0.3932727$$

$$N(d_1) = N(.50327) = 1 - 0.3072 = 0.6928$$

$$N(d_2) = N(.39327) = 1 - 0.3471 = 0.6529$$

$$\text{Value of Option} = 415 (.6928) - \frac{400}{e^{(.05)(.25)}} (.6529)$$

$$= 287.512 - \frac{400}{1.012578} (.6529) = 287.512 - 257.916 = ₹ 29.60$$

NB : $N(0.39327)$ can also be find as under :

Step 1: From table of area under normal curve find the area of variable 0.39 i.e. 0.6517.

Step 2: From table of area under normal curve find the area of variable 0.40.

Step 3: Find out the difference between above two variables and areas under normal curve.

Step 4 : Using interpolation method find out the value of 0.00327. Which is as follows:

$$\frac{0.0037}{0.01} \times 0.00327 = 0.0012$$

Step 5: Add this value, computed above to the $N(0.39)$. Thus $N(0.39327)$
 $= 0.6517 + 0.0012 = 0.6529$

Since market price of ₹ 25 is less than ₹ 29.60 (as per Black Scholes Valuation model) indicate that option is underpriced, hence worth buying.

(ii) If the current price is taken as ₹ 380 the computations are as follows:

$$d_1 = \frac{\ln\left(\frac{380}{400}\right) + \left[.05 + \frac{1}{2} (.22)^2\right] .25}{.22 \sqrt{.25}} = \frac{-0.05129 + .01855}{.11} = -0.297636$$

$$d_2 = \frac{\ln\left(\frac{380}{400}\right) + \left[.05 - \frac{1}{2} (.22)^2\right] .25}{.22 \sqrt{.25}} = \frac{-0.05129 + .00645}{.11} = -0.407636$$

$$V_o = V_s N(d_1) - \frac{E}{e^{rt}} N(d_2)$$

$$N(d_1) = N(-0.297636) = 0.3830$$

$$N(d_2) = N(-0.407636) = 0.3418$$

$$380 (.3830) - \frac{400}{e^{(.05)(.25)}} \times (.3418)$$

$$145.54 - \frac{400}{1.012578} (.3418) = 145.54 - 135.02 = ₹ 10.52$$

(iii) Value of call option = ₹ 10.52

Current Market Value = ₹ 415

$$\text{Present Value of Exercise Price} = \frac{400}{1.0125} = 395.06 \text{ or } \frac{400}{1.012578} = 395.03$$

Value of Put Option can be find by using Put Call Parity relationship as follows:

$$V_p = -V_s + V_c + PV(E)$$

$$V_p = -380 + 10.52 + 395.06 = 25.58$$

$$= ₹ 25.58 \text{ Ans}$$

$$\text{or } -380 + 10.52 + 395.03 = 25.55$$

$$= ₹ 25.55$$

- (iv) Since dividend is expected to be paid in two months time we have to adjust the share price and then use Black Scholes model to value the option:

Present Value of Dividend (using continuous discounting) = Dividend $\times e^{-rt}$

$$= ₹ 10 \times e^{-.05 \times .16666}$$

$$= ₹ 10 \times e^{-.008333}$$

$$= ₹ 9.917 \text{ (Please refer Exponential Table)}$$

Adjusted price of shares is ₹ 408 – 9.917 = ₹ 398.083

This can be used in Black Scholes model

$$d_1 = \frac{\ln\left(\frac{398.083}{400}\right) + \left[.05 + \frac{1}{2} (.22)^2\right] .25}{.22 \sqrt{.25}} = \frac{-.00481 + .01855}{.11} = 0.125$$

$$d_2 = \frac{\ln\left(\frac{398.083}{400}\right) + \left[.05 - \frac{1}{2} (.22)^2\right] .25}{.22 \sqrt{.25}} = \frac{-.00481 + .00645}{.11} = 0.015$$

$$N(d_1) = N(0.125) = .5498$$

$$N(d_2) = N(0.015) = .5060$$

$$\text{Value of Option} = 398.083 (.5498) - \frac{400}{e^{(.05) (.25)}} (.5060)$$

$$218.866 - \frac{400}{e^{.0125}} (.5060)$$

$$218.866 - \frac{400}{1.012578} (.5060) = 218.866 - 199.8858 = ₹ 18.98$$

7.4 Greeks

The Greeks are a collection of statistical values (expressed as percentages) that give the investor a better overall view of how a stock has been performing. These statistical values can be helpful in deciding what options strategies are best to use. The investor should remember that statistics show trends based on past performance. It is not guaranteed that the future performance of the stock will behave according to the historical numbers. These trends can change drastically based on new stock performance.

Before we discuss these statistical measures let us discuss the factors that affects the value of option as these statistical measures are related to changes in the in these factors.

7.4.1 Factors Affecting Value of an Option

There are a number of different mathematical formulae, or models, that are designed to compute the fair value of an option. You simply input all the variables (stock price, time, interest rates, dividends and future volatility), and you get an answer that tells you what an option should be worth. Here are the general effects the variables have on an option's price:

(a) **Price Movement of the Underlying:** The value of calls and puts are affected by changes in the underlying stock price in a relatively straightforward manner. When the stock price goes up, calls should gain in value and puts should decrease. Put options should increase in value and calls should drop as the stock price falls.

(b) **Time till expiry:** The option's future expiry, at which time it may become worthless, is an important and key factor of every option strategy. Ultimately, time can determine whether your option trading decisions are profitable. To make money in options over the long term, you need to understand the impact of time on stock and option positions.

With stocks, time is a trader's ally as the stocks of quality companies tend to rise over long periods of time. But time is the enemy of the options buyer. If days pass without any significant change in the stock price, there is a decline in the value of the option. Also, the value of an option declines more rapidly as the option approaches the expiration day. That is good news for the option seller, who tries to benefit from time decay, especially during that final month when it occurs most rapidly.

(c) **Volatility in Stock Prices:** Volatility can be understood via a measure called Statistical (sometimes called historical) Volatility, or SV for short. SV is a statistical measure of the past price movements of the stock; it tells you how volatile the stock has actually been over a given period of time.

But to give you an accurate fair value for an option, option pricing models require you to put in what the future volatility of the stock will be during the life of the option. Naturally, option traders don't know what that will be, so they have to try to guess. To do this, they work the options pricing model "backwards" (to put it in simple terms). After all, you already know the price at which the option is trading; you can also find the other variables (stock price, interest rates, dividends, and the time left in the option) with just a bit of research. So, the only missing number is future volatility, which you can calculate from the equation.

(d) **Interest Rate-** Another feature which affects the value of an Option is the time value of money. The greater the interest rates, the present value of the future exercise price are less.

Now let us discuss these measures.

7.4.2 Delta

A by-product of the Black-Scholes model is the calculation of the delta. It is the degree to which an option price will move given a small change in the underlying stock price. For example, option price (with a delta of 0.5) will move half a rupee for every full rupee movement in the underlying stock.

A deeply out-of-the-money call will have a delta very close to zero; a deeply in-the-money call will have a delta very close to 1.

The formula for a delta of a European call on a non-dividend paying stock is:

Delta = $N(d_1)$ (see Black-Scholes formula above for d_1)

Call Deltas are positive; Put Deltas are negative, reflecting the fact that the Put option price and the underlying stock price are inversely related. The Put Delta is equal to (Call Delta – 1).

As discussed earlier the delta is often called the Hedge Ratio. If you have a portfolio consisting short 'n' options (e.g., you have written n calls) and holding number of shares (units of the underlying i.e., n multiplied by the delta). This gives you a riskless position - i.e., a portfolio which would be worth the same whether the stock price rose by a very small amount or fell by a very small amount. In such a "delta neutral" portfolio any gain in the value of the shares held due to a rise in the share price would be exactly offset by a loss on the value of the calls written, and vice versa.

Note that as the Delta changes with the stock price and time to expiration the number of shares would need to be continually adjusted to maintain the hedge. How quickly the delta changes with the stock price are given by 'Gamma'.

In addition to Delta there are some other "Greeks" which some find useful when constructing option strategies.

7.4.3 Gamma

It measures how fast the Delta changes for small changes in the underlying stock price i.e. the Delta of the Delta. If you are hedging a portfolio using the Delta-hedge technique then you will want to keep gamma as small as possible, the smaller it is the less often you will have to adjust the hedge to maintain a delta neutral position. If gamma is too large, a small change in stock price could wreck your hedge. Adjusting gamma, however, can be tricky and is generally done using options i.e. it cannot be done by selling or buying underlying asset rather by selling or buying options.

7.4.4 Theta

It is change in the option price upon one day decrease in time to expiration. Basically, it is a measure of time decay. Unless you and your portfolio are travelling at close to the speed of light the passage of time is constant and inexorable. Thus, hedging a portfolio against time decay, the effects of which are completely predictable, would be pointless.

7.4.5 Rho

The change in option price given a one percentage point change in the risk-free interest rate. It is sensitivity of option value to change in interest rate. Rho indicates the absolute change in option value for a one percent change in the interest rate. For example, a Rho of 0.06 indicates the option's theoretical value will increase by 0.06 if the interest rate is decreased by 1.0.

7.4.6 Vega

Sensitivity of option value to change in volatility. Vega indicates an absolute change in option value for a one percent change in volatility. For example, a Vega of 0.09 indicates an absolute change in the option's theoretical value will increase by 0.09 if the volatility percentage is increased by 1.0 or decreased by 0.09 if the volatility percentage is decreased by 1.0. Results may not be exact due to rounding. It can also be stated as the change in option price given a one percentage point change in volatility. Like delta and gamma, Vega is also used for hedging.

7.5 Exotic Options

Exotic options are the classes of option contracts with structure and features different from plain vanilla options i.e. American and European style options. Not only that Exotic options are different from these vanilla options in their expiration dates also. As mentioned earlier an American option allows the option buyer to exercise its right at any time on or before expiration date. On the other hand European option can be exercised only at the expiry of maturity period. Exotic option is some type of hybrid of American and European options and hence falls somewhere in between these options.

7.5.1 Exotic Vs. Traditional Option

- a. An exotic option can vary in terms of pay off and time of exercise.
- b. These options are more complex than vanilla options.
- c. Mostly Exotic options are traded in OTC market.

7.5.2 Types of Exotic Options

The most common types of Exotic options are as follows:

- (a) **Chooser Options:** This option provides a right to the buyer of option after a specified period of time to decide whether purchased option is a call option or put option. It is to be noted that the decision can be made within a specified period prior to the expiration of contracts.
- (b) **Compound Options:** Also called split fee option or 'option on option'. As the name suggests this option provides a right or choice not an obligation to buy another option at specific price on the expiry of first maturity date. Thus, it can be said in this option the underlying is an option. Further the payoff depends on the strike price of second option.
- (c) **Barrier options:** Though it is similar to plain vanilla call and put options, but unique feature of this option is that contract will become activated only if the price of the underlying reaches a certain price during a predetermined period.
- (d) **Binary Options:** Also known as 'Digital Option', this option contract guarantees the pay-off based on the happening of a specific event. If the event has occurred, the pay-off shall be pre-decided amount and if event it has not occurred then there will be no pay-off.

- (e) **Asian Options:** These are the option contracts whose pay off are determined by the average of the prices of the underlying over a predetermined period during the lifetime of the option.
- (f) **Bermuda Option:** It is somewhat a compromise between a European and American options. Contrary to American option where it can be exercised at any point of time, the exercise of this option is restricted to certain dates or on expiration like European option.
- (g) **Basket Options:** In this type of contracts the value of option instead of one underlying depends on the value of a portfolio i.e., a basket. Generally, this value is computed based on the weighted average of underlying constituting the basket.
- (h) **Spread Options:** As the name suggests the payoff of these type of options depend on difference between prices of two underlying.
- (i) **Look back options:** Unlike other type of options whose exercise prices are pre-decided, in this option on maturity date the holder of the option is given a choice to choose a most favourable strike price depending on the minimum and maximum price of an underlying achieved during the life time of option.

8. CREDIT DERIVATIVES

Credit Derivatives is summation of two terms, Credit + Derivatives. As we know that derivative implies value deriving from an underlying, and this underlying can be anything we discussed earlier i.e. stock, share, currency, interest etc.

Initially started in 1996, due to the need of the banking institutions to hedge their exposure of lending portfolios today it is one of the popular structured financial products.

Plainly speaking the financial products are subject to following two types of risks:

- (a) **Market Risk:** Due to adverse movement of the stock market, interest rates and foreign exchange rates.
- (b) **Credit Risk:** Also called counter party or default risk, this risk involves non-fulfilment of obligation by the counter party.

While, financial derivatives can be used to hedge the market risk, credit derivatives emerged out to mitigate the credit risk. Accordingly, the credit derivative is a mechanism whereby the risk is transferred from the risk averse investor to those who wish to assume the risk.

Although there are number of credit derivative products but in this chapter, we shall discuss two types of credit Derivatives 'Collateralised Debt Obligation' and 'Credit Default Swap'.

8.1 Collateralized Debt Obligations (CDOs)

While in securitization the securities issued by SPV are backed by the loans and receivables the CDOs are backed by pool of bonds, asset backed securities, REITs, and other CDOs. Accordingly, it covers both Collateralized Bond Obligations (CBOs) and Collateralized Loan Obligations (CLOs).

8.1.1 Types of CDOs

The various types of CDOs are as follows:

(a) Cash Flow Collateralized Debt Obligations (Cash CDOs): Cash CDO is CDO which is backed by cash market debt or securities which normally have low risk weight. This structure mainly relies on the collateral's risk weight and collateral's ability to generate sufficient cash to pay off the securities issued by SPV.

(b) Synthetic Collateralized Debt Obligations: It is similar to Cash Flow CDOs but with the difference that instead of transferring ownerships of collateral to SPV (a separate legal entity), synthetic CDOs are structured in such a manner that credit risk is transferred by the originator without actual transfer of assets.

Normally the structure resembles the hedge funds where in the value of portfolio of CDO is dependent upon the value of collateralized instruments and market value of CDOs depends on the portfolio manager's ability to generate adequate cash and meeting the cash flow obligations (principal and interest) in timely manner.

While in cash CDO the collateral assets are moved away from Balance Sheet, in synthetic CDO there is no actual transfer of assets instead economic effect is transferred.

This effect of transfer economic risk is achieved by creating provision for Credit Default Swap (CDS) or by issue of Credit Linked Notes (CLN), a form of liability.

Accordingly, this structure is mainly used to hedge the risk rather than balance sheet funding. Further, for banks, this structure also allows the customer's relations to be unaffected. This was started mainly by banks who want to hedge the credit risk but not interested in taking administrative burden of sale of assets through securitization.

Technically, speaking synthetic CDO obtain regulatory capital relief benefits vis-à-vis cash CDOs. Further, they are more popular in European market due to the reason of less legal documentation requirements. Synthetic CDOs can also be categorized as follows:

- (i) Unfunded: - It will be comprised only CDs.
- (ii) Fully Funded: - It will be through issue of Credit Linked Notes (CLN).
- (iii) Partially Funded: - It will be partially through issue of CLN and partially through CDs.

(c) **Arbitrage CDOs:** Basically, in Arbitrage CDOs, the issuer captures the spread between the return realized collateral underlying the CDO and cost of borrowing to purchase these collaterals. In addition to this issuer also collects the fee for the management of CDOs. This arbitrage arises due to acquisition of relatively high yielding securities with large spread from open market.

8.1.2 Risks involved in CDOs

CDOs are structured products and just like other financial products are also subject to various types of Risk.

The main types of risk associated with investment in CDOs are as follows:

(a) **Default Risk:** - Also called 'credit risk', it emanates from the default of underlying party to the instruments. The prime sufferers of these types of risks are equity or junior tranche in the waterfall.

(b) **Interest Rate Risk:** - Also called Basis risk and mainly arises due to different basis of interest rates. For example, asset may be based on floating interest rate but the liability may be based on fixed interest rates. Though this type of risk is quite difficult to manage fully but commonly used techniques such as swaps, caps, floors, collars etc. can be used to mitigate the interest rate risk.

(c) **Liquidity Risk:** - Another major type of risk by which CDOs are affected is liquidity risks as there may be mismatch in coupon receipts and payments.

(d) **Prepayment Risk:** - This risk results from unscheduled or unexpected repayment of principal amount underlying the security. Generally, this risk arises in case assets are subject to fixed rate of interest and the debtors have a call option. Since, in case of falling interest rates they may pay back the money.

(e) **Reinvestment Risk:** - This risk is generic in nature as the CDO manager may not find adequate opportunity to reinvest the proceeds when allowed for substitutions.

(f) **Foreign Exchange Risk:** - Sometimes CDOs are comprised of debts and loans from countries other than the country of issue. In such a case, in addition to above mentioned risks, CDOs are also subject to the foreign exchange rate risk.

8.2 Credit Default Swaps (CDSs)

It is a combination of following 3 words:

Credit : Loan given

Default : Non payment

Swap : Exchange of Liability or Risk

Accordingly, CDS can be defined as an insurance (not in stricter sense) against the risk of default on a debt which may be debentures, bonds etc.

Under this arrangement, one party (called buyer) needing protection against the default pays a periodic premium to another party (called seller), who in turn assumes the default risk. Hence, in case default takes place then there will be settlement and in case no default takes place no cash flow will accrue to the buyer alike option contract and agreement is terminated. Although it resembles the options but since element of choice is not there it more resembles the swap arrangements.

Amount of premium mainly depends on the price of underlying and especially when the credit risk is more.

8.2.1 Main Features of CDS

The main features of CDS are as follows:

- (a) CDS is a non-standardized private contract between the buyer and seller. Therefore, it is covered in the category of Forward Contracts.
- (b) They are normally not traded on any exchange and hence remains free from the regulations of Governing Body.
- (c) The International Swap and Derivative Association (ISAD) publishes the guidelines and general rules used normally to carry out CDS contracts.
- (d) CDS can be purchased from third party to protect itself from default of borrowers.
- (e) Similarly, an individual investor who is buying bonds from a company can purchase CDS to protect his investment from insolvency of that company. Thus, this increases the level of confidence of investor in Bonds purchased.
- (f) The cost or premium of CDS has a positive relationship with risk attached with loans. Therefore, higher the risk attached to Bonds or loans, higher will be premium or cost of CDS.
- (g) If an investor buys a CDS without being exposed to credit risk of the underlying bond issuer, it is called "naked CDS".

8.2.2 Uses of Credit Default Swap

Following are the main purposes for which CDS can be used:

- (a) **Hedging-** Main purpose of using CDS is to neutralize or reduce a risk to which CDS is exposed to. Thus, by buying CDS, risk can be passed on to CDS seller or writer.
- (b) **Arbitrage-** It involves buying a CDS and entering into an asset swap. For example, a fixed coupon payment of a bond is swapped against a floating interest stream.
- (c) **Speculation-** CDS can also be used to make profit by exploiting price changes. For example, a CDS writer assumed risk of default, will gain from contract if credit risk does not materialize during the tenure of contract or if compensation received exceeds potential payout.

8.2.3 Parties to CDS

In a CDS at least three parties are involved which are as follows:

- i. **The initial borrowers-** It is also called a 'reference entity', which are owing a loan or bond obligation.
- ii. **Buyer-** It is also called 'investor' i.e. the buyer of protection. The buyer will make regular payment to the seller for the protection from default or credit event of reference entity.
- iii. **Seller-** It is also called 'writer' of the CDS and makes payment to buyer in the event of credit event of reference entity. It receives a regular pay off from the buyer of CDS.

Example

Suppose BB Corp. buys CDS from SS Bank for the Bonds amounting \$ 10 million of Danger Corp. In such case, the BB Corp. will become the buyer, SS Bank becomes seller and Danger Corp. becomes the reference entity. BB Corp. will make regular payment to SS Bank of the premium and if Danger Corp. defaults on its debts, the BB Corp. will receive one time payment and CDS contract is terminated.

8.2.4 Settlement of CDS

Broadly, following are main ways of settlement of CDS.

- (i) **Physical Settlement –** This is the traditional method of settlement. It involves the delivery of Bonds or debts of the reference entity by the buyer to the seller and seller pays the buyer the par value.

For example, as mentioned above suppose Danger Corp. defaults then SS Bank will pay \$ 10 Million to BB Corp. and BB Corp will deliver \$10 Million face value of Bonds to SS Bank.

- (ii) **Cash Settlement-** Under this arrangement seller pays the buyer the difference between par value and the market price of a debt (whatever may be the market value) of the reference entity. Continuing the above example suppose, the market value of Bonds is 30%, as market is of belief that bond holder will receive 30% of the money owed in case company goes into liquidation. Thus, the SS Bank shall pay BB Corp. \$ 10 Million - \$3 million (100% - 30%) = \$ 7 Million.

To make Cash settlement even more transparent, the credit event auction was developed. Credit event auction set a price for all market participants that choose to cash settlement.

9. REAL OPTIONS

Real Options methodology is an approach to capital budgeting that relies on Option Pricing theory to evaluate projects. Insights from option-based analysis can improve estimates of project value and, therefore, has potential, in many instances to significantly enhance project management. However, Real options approach is intended to supplement, and not replace, capital budgeting analyses based

on standard Discounted Cash Flow (DCF) methodologies that has been discussed at Intermediate Level.

9.1 How Real Option is different from Financial Option

Before we further discuss the various aspects of Real Option it is important to first understand How Real Option is different from Financial Option which is as follows:

Basis	Financial Options	Real Options
Underlying	Have underlying assets that are normally traded in the market i.e. shares, stocks, bonds, commodity etc.	Have underlying the projects that are not traded in the market.
Pay-off	In most of the cases it is specified in the contracts and hence is fixed.	It is estimated from the project cash flows and hence can be varied.
Exercise Period	Mostly the period of these options is short and can go maximum upto 1 year.	The period of these options mostly starts from the end of 1st year and higher than the Financial Options.
Approach	Since these options are normally traded in the market they are "Priced".	Since these options are used to make decisions, they are "Valued".

The following is a list of options that may exist in a capital budgeting project.

Long call:

- Right to invest at some future date, at a certain price.
- Generally, any flexibility to invest, to enter a business, to expand a business.

Long put:

- Right to sell at some future date at a certain price.
- Right to abandon at some future date at zero or certain price.
- Generally, any flexibility to disinvest, to exit from a business.

Short call:

- Promise to sell if the counterparty wants to buy.
- Generally, any commitment to disinvest upon the action of another party.

Short put:

- Promise to buy if the counterparty wants to sell.
- Generally, any commitment to invest upon the action of another party.

9.2 Valuation of Real Options

The methods employed to valuation of real options are same as used in valuation of Financial Options. However, sometimes it becomes difficult to identify the value of certain inputs. The various type of cash flows associated with Real Option can be analysed with cash flows involved in financial options and methods used in financial options can be employed easily.

Broadly, following methods are employed for Valuation of Financial Options.

- (a) Binomial Model
- (b) Risk Neutral Method
- (c) Black-Scholes Model

Note: Above 3 methods have been discussed in detail in earlier section.

9.3 Type of Real Options

Following are broad type of Real Options:

9.3.1 Growth Options

Sometimes it may be possible that some projects have a negative or insignificant NPV even then managers may be interested in accepting the project as it may enable companies to find considerable profitability and add values in future. This case of real option is like *European Call Option*.

Some of the examples of such options are as follows:

- Investment in R&D activities
- Heavy expenditure on advertisement
- Initial investment in foreign market to expand business in future
- Acquiring making rights
- Acquisition of vacant plot with an intention to develop it in future.

The purposes of making such investments are as follows:

- Defining the competitive position of firm hence it is called strategic investments.
- Gaining knowledge about project's from profitability.
- Providing the manufacturing and making flexibility to the firm.

Illustration 4

ABC Ltd. is a pharmaceutical company possessing a patent of a drug called 'Aidrex', a medicine for aids patient. Being an approach drug ABC Ltd. holds the right of production of drugs and its marketing. The period of patent is 15 years after which any other pharmaceutical company produce the drug with same formula. It is estimated that company shall require to incur \$ 12.5 million for

development and market of the drug. As per a survey conducted the expected present value of cashflows from the sale of drug during the period of 15 years shall be \$ 16.7 million. Cash flow from the previous similar type of drug have exhibited a variance of 26.8% of the present value of cashflows. The current yield on Treasury Bonds of similar duration (15 years) is 7.8%.

Determine the value of the patent.

Given

$$\ln(1.336) = 0.2897$$

$$e^{1.0005} = 0.3677 \text{ and } e^{-1.17} = 0.3104$$

Solution

The given solution is like valuation of stock option wherein delay in introduction of drug 'Aidrex' shall cause the loss of cashflow which is like payment of dividend.

To value the patent, we shall use Black Scholes Model for option pricing as follows:

Inputs

S (Spot Price) = The Present Value of Cashflows = \$16.7 million

E (Exercise Price) = Cost of Development Formula = \$ 12.5 million

σ^2 (Variance of Cash flow) = 26.8% i.e. 0.27

R (Risk Free Rate of Return) = 7.8%

D (Expected cost of Delays) = $\frac{1}{15} = 0.0667$ i.e. 6.67%

Value call option

$$C = Se^{-df} - Ee^{-rt} N(d_2)$$

$$d_1 = \frac{\ln(S/E) + [R - D + (\frac{1}{2})\sigma^2] t}{\sigma\sqrt{t}}$$

$$d_2 = d_1 - \sigma\sqrt{t}$$

Accordingly,

$$d_1 = \frac{\ln(16.7/12.5) + [0.078 - 0.0667 + (\frac{1}{2})(0.268)] 15}{\sqrt{0.268} \sqrt{15}}$$

$$D_1 = \frac{0.2897 + (0.1453)15}{0.5177 \times 3.8730}$$

$$D_1 = \frac{0.2897 + 2.1795}{2.005}$$

$$D_1 = \frac{2.4692}{2.005} = 1.2315$$

$$d_2 = 1.2315 - 2.005$$

$$d_2 = -0.7735$$

$$N(d_1) = 0.8910$$

$$N(d_2) = 0.2196$$

Value of Patent

$$= 16.7 \times e^{-0.0667 \times 15} \times 0.8910 - 12.5 \times e^{-0.078 \times 15} \times 0.2196$$

$$= 16.7 \times 0.3677 \times 0.8910 - 12.5 \times 0.3104 \times 0.2196$$

$$= 5.471 - 0.852 = 4.619$$

Thus, the value of patents is \$ 4.619 million

9.3.2 Abandonment Option

As we have already studied in the topic of Capital Budgeting that once funds have been committed in any Capital Budgeting project it cannot be reverted without incurring a heavy loss. However, in some cases due to change in economic conditions the firm may like to opt for abandoning the project without incurring further huge losses.

The option to abandon the project is similar to an *American Put Option* where option to abandon the project shall be exercised if value derived from project's assets is more than PV of continuing the project for one or more period.

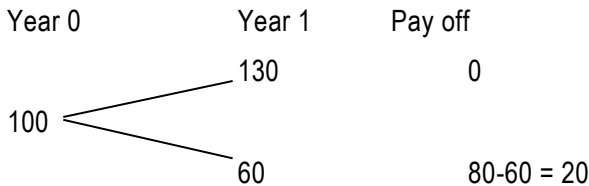
Illustration 5

IPL already in production of Fertilizer is considering a proposal of building a new plant to produce pesticides. Suppose the PV of proposal is ₹ 100 crore without the abandonment option. However, if market conditions for pesticide turns out to be favourable the PV of proposal shall increase by 30%. On the other hand, market conditions remain sluggish the PV of the proposal shall be reduced by 40%. In case company is not interested in continuation of the project it can be disposed of for ₹ 80 crore.

If the risk-free rate of interest is 8% then what will be value of abandonment option.

Solution

Decision Tree showing pay off



First of all we shall calculate probability of high demand (P) using risk neutral method as follows:

$$8\% = p \times 30\% + (1-p) \times (-40\%)$$

$$0.08 = 0.30p - 0.40 + 0.40p$$

$$p = \frac{0.48}{0.70} = 0.686$$

The value of abandonment option will be as follows:

Expected Payoff at Year 1

$$= p \times 0 + [(1-p) \times 20]$$

$$= 0.686 \times 0 + [0.314 \times 20]$$

$$= ₹ 6.28 \text{ crore}$$

Since expected pay off at year 1 is ₹ 6.28 crore. Present value of expected pay off will be:

$$\frac{6.28}{1.08} = ₹ 5.81 \text{ crore.}$$

This is the value of abandonment option (Put Option).

9.3.3 Timing Option

In traditional capital budgeting the project can either be accepted or rejected, implying that this will be undertaken or forever not. However, in real life situation sometimes a third choice also arises i.e., delay the decision until later, i.e., option when to invest. Possible reasons for this delay may be availability of better information or ideas later. This case of real option is like *American Call Option*.

Illustration 6

Suppose MIS Ltd. is considering installation of solar electricity generating plant for light the staff quarters. The plant shall cost ₹ 2.50 crore and shall lead to saving in electricity expenses at the current tariff by ₹ 21 lakh per year forever.

However, with change in Government in state, the rate of electricity is subject to change. Accordingly, the saving in electricity can be of ₹ 12 lakh or ₹ 35 lakh per year and forever.

Assuming WACC of MIS Ltd. is 10% and risk-free rate of rate of return is 8%.

Decide whether MIS Ltd. should accept the project or wait and see.

Solution

Here we shall evaluate NPV in two possible situations:

(1) As on Today

At cost of Capital of 10%, the value of saving forever = $\frac{₹ 21 \text{ lakhs}}{0.10} = ₹ 2.1 \text{ crore}$

NPV = ₹ 2.1 crore - ₹ 2.5 crore = - ₹ 0.4 crore

Since NPV is negative, it does not worth to accept the project.

(2) After one Year

After one year these are two possible situations, either rate of electricity decreases or increase.

(a) If price of electricity increases

At cost of Capital of 10%, the value of saving forever = $\frac{₹ 35 \text{ lakh}}{0.10} = ₹ 3.50 \text{ crore}$

The position of the NPV will be as follows:

= ₹ 3.50 crore - ₹ 2.50 crore = ₹ 1 crore

And Rate of Return will be $(3.5/2.5) - 1 = 0.40$ is 40%

(b) If the price of electricity decreases, then value of saving forever will be

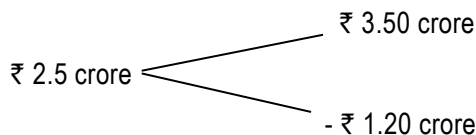
At cost of Capital of 10%, the value of saving forever = $\frac{12 \text{ lakh}}{0.10} = ₹ 1.20 \text{ crore}$

The position of the NPV will be as follows:

= ₹ 1.20 crore - ₹ 2.5 crore = - ₹ 1.3 crore

and Rate of Return will be $(1.2/2.5) - 1 = -0.52$ i.e. - 52.00%

Diagrammatically it can be shown below



Let prob. of price increase be p . Then using Risk Neutral Method, the risk-free rate of return will be equal to expected saving as follows:

$$p \times 0.40 + (1-p) (-0.52) = 0.08$$

$$0.40p - 0.52 + 0.52p = 0.08$$

$$0.92p = 0.60$$

$$p = 0.652$$

Hence, expected pay off = $0.652 \times ₹ 1 \text{ crore} + 0.348 \times (- ₹ 1.30 \text{ crore}) = ₹ 19.96 \text{ lakh}$.

PV of Pay off after one year = $₹ 19.96 \text{ lakh} / 1.08 = ₹ 18.48 \text{ lakh}$.

Thus, it shall be advisable to wait and see as NPV may turn out to be positive after one year.

10. COMMODITY DERIVATIVES

Trading in commodity derivatives first started to protect farmers from the risk of the value of their crop going below the cost price of their produce. Derivative contracts were offered on various agricultural products like cotton, rice, coffee, wheat, pepper etc.

The first organized exchange, the Chicago Board of Trade (CBOT) -- with standardized contracts on various commodities -- was established in 1848. In 1874, the Chicago Produce Exchange - which is now known as Chicago Mercantile Exchange (CME) was formed.

CBOT and CME are two of the largest commodity derivatives exchanges in the world.

10.1 Necessary Conditions to Introduce Commodity Derivatives

The commodity characteristic approach defines feasible commodities for derivatives trading based on an extensive list of required commodity attributes. It focuses on the technical aspects of the underlying commodity. The following attributes are considered crucial for qualifying for the derivatives trade:

- 1) a commodity should be durable and it should be possible to store it;
- 2) units must be homogeneous;
- 3) the commodity must be subject to frequent price fluctuations with wide amplitude; supply and demand must be large;
- 4) supply must flow naturally to market and there must be breakdowns in an existing pattern of forward contracting.

The first attribute, durability and storability, has received considerable attention in commodity finance, since one of the economic functions often attributed to commodity derivatives markets is the temporal allocation of stocks. The commodity derivatives market is an integral part of this storage scenario because it provides a hedge against price risk for the carrier of stocks.

Since commodity derivatives contracts are standardized contracts, this approach requires the underlying product to be homogeneous, the second attribute, so that the underlying commodity as defined in the commodity derivatives contract corresponds with the commodity traded in the cash market. This allows for actual delivery in the commodity derivatives market.

The third attribute, a fluctuating price, is of great importance, since firms will feel little incentive to insure themselves against price risk if price changes are small. A broad cash market is important because a large supply of the commodity will make it difficult to establish dominance in the market

place and a broad cash market will tend to provide for a continuous and orderly meeting of supply and demand forces.

The last crucial attribute, breakdowns in an existing pattern of forward trading, indicates that cash market risk will have to be present for a commodity derivatives market to come into existence. Should all parties decide to eliminate each and every price fluctuation by using cash forward contracts for example, a commodity derivatives market would be of little interest.

A commodity derivative must reflect the commercial movement of a commodity both loosely and broadly enough, so that price distortions will not be a result of specifications in the contract. To warrant hedging, the contract must be as close a substitute for the cash commodity as possible. Hedging effectiveness is an important determinant in explaining the success of commodity derivatives and as a result considerable attention has been paid to the hedging effectiveness of commodity derivatives.

The total set of customer needs concerning commodity derivatives is differentiated into instrumental needs and convenience needs (see Figure 1). Customers will choose that “service-product” (futures, options, cash forwards, etc.) which best satisfy their needs, both instrumental and convenience, at an acceptable price.

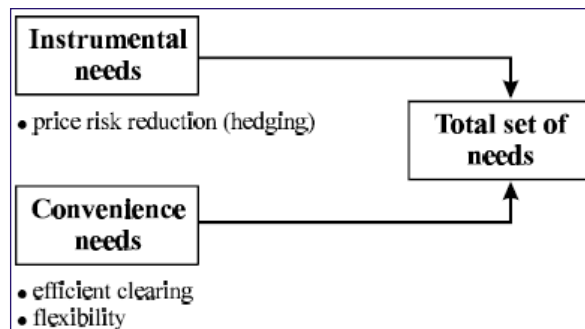


FIGURE 1

Instrumental needs are the hedgers' needs for price risk reduction. Hedgers wish to reduce, or, if possible, eliminate portfolio risks at low cost. The instrumental needs are related to the core service of the commodity derivatives market, which consists of reducing price variability to the customer. Not only do hedgers wish to reduce price risk, they also desire flexibility in doing business, easy access to the market, and an efficient clearing system. These needs are called convenience needs. They deal with the customer's need to be able to use the core service provided by the exchange with relative ease. The extent to which the commodity derivatives exchange is able to satisfy convenience needs determines the process quality. The service offering is not restricted to the core service, but has to be complemented by so-called peripheral services.

10.2 Investing in Commodity Derivatives

Commodity derivatives, which were traditionally developed for risk management purposes, are now growing in popularity as an investment tool. Most of the trading in the commodity derivatives market is being done by people who have no need for the commodity itself.

They just speculate on the direction of the price of these commodities, hoping to make money if the price moves in their favour.

The commodity derivatives market is a direct way to invest in commodities rather than investing in the companies that trade in those commodities.

For example, an investor can invest directly in a steel derivative rather than investing in the shares of Tata Steel. It is easier to forecast the price of commodities based on their demand and supply forecasts as compared to forecasting the price of the shares of a company which depend on many other factors than just the demand and supply of the products they manufacture and sell or trade in.

Also, derivatives are much cheaper to trade in as only a small sum of money is required to buy a derivative contract.

Let us assume that an investor buys a tonne of soybean for ₹ 8,700 in anticipation that the prices will rise to ₹ 9,000 by June 30, 2013. He will be able to make a profit of ₹ 300 on his investment, which is 3.4%. Compare this to the scenario if the investor had decided to buy soybean futures instead.

Before we look into how investment in a derivative contract works, we must familiarize ourselves with the buyer and the seller of a derivative contract. A buyer of a derivative contract is a person who pays an initial margin to buy the right to buy or sell a commodity at a certain price and a certain date in the future.

On the other hand, the seller accepts the margin and agrees to fulfill the agreed terms of the contract by buying or selling the commodity at the agreed price on the maturity date of the contract.

Now let us say the investor buys soybean futures contract to buy one tonne of soybean for ₹ 8,700 (exercise price) on November 30, 2013. The contract is available by paying an initial margin of 10%, i.e. ₹ 870. Note that the investor needs to invest only ₹ 870 here.

On November 30, 2013, the price of soybean in the market is, say, ₹ 9,000 (known as Spot Price -- Spot Price is the current market price of the commodity at any point in time).

The investor can take the delivery of one tonne of soybean at ₹ 8,700 and immediately sell it in the market for ₹ 9,000, making a profit of ₹ 300. So the return on the investment of ₹ 870 is 34.5%. On the contrary, if the price of soybean drops to ₹ 8,400 the investor will end up making a loss of 34.5%.

If the investor wants, instead of taking the delivery of the commodity upon maturity of the contract, an option to settle the contract in cash also exists. Cash settlement comprises exchange of the difference in the spot price of the commodity and the exercise price as per the futures contract.

At present, the option of cash settlement lies only with the seller of the contract. If the seller decides to make or take delivery upon maturity, the buyer of the contract has to fulfill his obligation by either taking or making delivery of the commodity, depending on the specifications of the contract.

In the above example, if the seller decides to go for cash settlement, the contract can be settled by the seller by paying ₹ 300 to the buyer, which is the difference in the spot price of the commodity and the exercise price. Once again, the return on the investment of ₹ 870 is 34.5%.

The above example shows that with very little investment, the commodity futures market offers scope to make big bucks. However, trading in derivatives is highly risky because just as there are high returns to be earned if prices move in favour of the investors, an unfavourable move results in huge losses.

The most critical function in a commodity derivatives exchange is the settlement and clearing of trades. Commodity derivatives can involve the exchange of funds and goods. The exchanges have a separate body to handle all the settlements, known as the clearing house.

For example, the holder of a futures contract to buy soybean might choose to take delivery of soya bean rather than closing his position before maturity. The function of the clearing house or clearing organization, in such a case, is to take care of possible problems of default by the other party involved by standardizing and simplifying transaction processing between participants and the organization.

Certain special characteristics/benefits of Commodity derivatives trading are:

- ❖ To complement investment in companies that use commodities;
- ❖ To invest in a country's consumption and production;
- ❖ No dividends, only returns from price increases.

In spite of the surge in the turnover of the commodity exchanges in recent years, a lot of work in terms of policy liberalization, setting up the right legal system, creating the necessary infrastructure, large-scale training programs, etc. still needs to be done in order to catch up with the developed commodity derivative markets.

10.3 Commodity Market

Commodity markets in early time are believed to have originated in Sumer where small baked clay tokens in the shape of sheep or goats were used in trade. Sealed in clay vessels with a certain number of such tokens, with that number written on the outside, they represented a promise to deliver that number.

In modern times, commodity markets represent markets where raw or primary products are exchanged. These raw commodities are traded on regulated, commodity exchanges in which they are bought and sold in standardized contracts.

Some of the advantages of commodity markets are:

- ❖ Most money managers prefer derivatives to tangible commodities;

- ❖ Less hassle (delivery, etc);
- ❖ Allows indirect investment in real assets that could provide an additional hedge against inflation risk.

10.4 Commodity Futures

Almost all the commodities were allowed to be traded in the futures market from April 2003. To make trading in commodity futures more transparent and successful, multi-commodity exchanges at national level were also conceived and these next generation exchanges were allowed to start futures trading in commodities on-line.

The process of trading commodities is also known as Futures Trading. Unlike other kinds of investments, such as stocks and bonds, when you trade futures, you do not actually buy anything or own anything. You are speculating on the future direction of the price in the commodity you are trading. This is like a bet on future price direction. The terms "buy" and "sell" merely indicate the direction you expect future prices will take.

If, for instance, you were speculating in corn, you would buy a futures contract if you thought the price would be going up in the future. You would sell a futures contract if you thought the price would go down. For every trade, there is always a buyer and a seller. Neither person has to own any corn to participate. He must only deposit sufficient capital with a brokerage firm to ensure that he will be able to pay the losses if his trades lose money.

On one side of a transaction may be a producer like a farmer. He has a field full of corn growing on his farm. It won't be ready for harvest for another three months. If he is worried about the price going down during that time, he can sell futures contracts equivalent to the size of his crop and deliver his corn to fulfill his obligation under the contract. Regardless of how the price of corn changes in the three months until his crop will be ready for delivery, he is guaranteed to be paid the current price.

On the other side of the transaction might be a producer such as a cereal manufacturer who needs to buy lots of corn. The manufacturer, such as Kellogg, may be concerned that in the next three months the price of corn will go up, and it will have to pay more than the current price. To protect against this, Kellogg can buy futures contracts at the current price. In three months, Kellogg can fulfill its obligation under the contracts by taking delivery of the corn. This guarantees that regardless of how the price moves in the next three months, Kellogg will pay no more than the current price for its commodity.

In addition to agricultural commodities, there are futures for financial instruments and intangibles such as currencies, bonds and stock market indexes. Each futures market has producers and consumers who need to hedge their risk from future price changes. The speculators, who do not actually deal in the physical commodities, are there to provide liquidity. This maintains an orderly market where price changes from one trade to the next are small.

Rather than taking delivery or making delivery, the speculator merely offsets his position at some time before the date set for future delivery. If price has moved in the right direction, he will earn profit, if not, he will lose.

Advantages of Commodity Futures

Some of the advantages of commodity futures are:

- Easiest and cheapest way to invest in commodities
- 3 Major Categories like Agricultural products (soft commodities) –fibers, grains, food, livestock; Energy – crude oil, heating oil, natural gas; and Metals – copper, aluminium, gold, silver, platinum

10.5 Commodity Swaps

Producers need to manage their exposure to fluctuations in the prices for their commodities. They are primarily concerned with fixing prices on contracts to sell their produce. A gold producer wants to hedge his losses attributable to a fall in the price of gold for his current gold inventory. A cattle farmer wants to hedge his exposure to changes in the price of his livestock.

End-users need to hedge the prices at which they can purchase these commodities. A university might want to lock in the price at which it purchases electricity to supply its air conditioning units for the upcoming summer months. An airline wants to lock in the price of the jet fuel it needs to purchase in order to satisfy the peak in seasonal demand for travel.

Speculators are funds or individual investors who can either buy or sell commodities by participating in the global commodities market. While many may argue that their involvement is fundamentally destabilizing, it is the liquidity they provide in normal markets that facilitates the business of the producer and of the end-user.

Why would speculators look at the commodities markets? Traditionally, they may have wanted a hedge against inflation. If the general price level is going up, it is probably attributable to increases in input prices. Or, speculators may see tremendous opportunity in commodity markets. Some analysts argue that commodity markets are more technically-driven or more likely to show a persistent trend.

10.5.1 Types of Commodity Swaps

There are two types of commodity swaps: fixed-floating or commodity-for-interest.

(a) Fixed-Floating Swaps: They are just like the fixed-floating swaps in the interest rate swap market with the exception that both indices are commodity based indices.

General market indices in the international commodities market with which many people would be familiar include the S&P Goldman Sachs Commodities Index (S&PGSCI) and the Commodities Research Board Index (CRB). These two indices place different weights on the various commodities so they will be used according to the swap agent's requirements.

(b) Commodity-for-Interest Swaps: They are similar to the equity swap in which a total return on the commodity in question is exchanged for some money market rate (plus or minus a spread).

10.5.2 Valuing Commodity Swaps

In pricing commodity swaps, we can think of the swap as a strip of forwards, each priced at inception with zero market value (in a present value sense). Thinking of a swap as a strip of at-the-money forwards is also a useful and intuitive way of interpreting interest rate swaps or equity swaps.

Commodity swaps are characterized by some peculiarities. These include the following factors for which we must account:

- (i) The cost of hedging;
- (ii) The institutional structure of the particular commodity market in question;
- (iii) The liquidity of the underlying commodity market;
- (iv) Seasonality and its effects on the underlying commodity market;
- (v) The variability of the futures bid/offer spread;
- (vi) Brokerage fees; and
- (vii) Credit risk, capital costs and administrative costs.

Some of these factors must be extended to the pricing and hedging of interest rate swaps, currency swaps and equity swaps as well. The idiosyncratic nature of the commodity markets refers to the limited number of participants in these markets (naturally begging questions of liquidity and market information), the unique factors driving these markets, the inter-relations with cognate markets and the individual participants in these markets.

10.6 Hedging with Commodity Derivatives

Many times, when using commodity derivatives to hedge an exposure to a financial price, there is not one exact contract that can be used to hedge the exposure. If you are trying to hedge the value of a particular type of refined chemical derived from crude oil, you may not find a listed contract for that individual product. You will find an over-the-counter price if you are lucky.

They look at the correlation (or the degree to which prices in the individual chemical trade with respect to some other more liquid object, such as crude oil) for clues as to how to price the OTC product that they offer you. They make assumptions about the stability of the correlation and its volatility and they use that to "shade" the price that they show you.

Correlation is an un-hedgable risk for the OTC market maker, though. There is very little that he can do if the correlation breaks down.

For example, if all of a sudden, the price for your individual chemical starts dropping faster than the correlation of the chemical's price with crude oil suggests it should, the OTC dealer has to start dumping more crude oil in order to compensate.

It is a very risky business. The OTC market maker's best hope is to see enough "two-way" business involving end-users and producers so that his exposure is "naturally" hedged by people seeking to benefit from price movement in either direction.

Commodity swaps and commodity derivatives are a useful and important tool employed by most leading energy, chemical and agricultural corporations in today's world.

Note: Please note other forms of Swaps such as Currency Swap and Interest Rate Swap have been discussed in the respective chapters.

11. WEATHER DERIVATIVES

While there are some companies whose performance are completely unaffected by weather but there are many companies whose performance is liable to be adversely affected by the weather. For example, airline companies, juice manufacturing companies etc. Especially farmers are highly exposed to weather. To hedge this risk, instruments are required like instruments are used to hedge foreign exchange and other financial risks. This led to rise of a new class of financial instruments - Weather Derivatives- has been introduced to enable businesses to manage their volumetric risk resulting from unfavourable weather patterns. Just as traditional contingent claims, whose payoffs depend upon the price of some fundamental, a weather derivative has its underlying "asset", a weather measure. "Weather", of course, has several dimensions: rainfall, temperature, humidity, wind speed, etc. There is a fundamental difference between weather and traditional derivative contracts concerning the hedge objective. The underlying of weather derivatives is represented by a weather measure, which influences the trading volume of goods. This, in turn, means that the primary objective of weather derivatives is to hedge volume risk, rather than price risk, that results from a change in the demand for goods due to a change in weather.

The first weather transaction was executed in 1997 in the Over the Counter (OTC) market by Aquila Energy Company. The market was jump started during the warm Midwest/Northeast El Nino winter of 1997-1998, when the unusual higher temperatures induced companies to protect themselves from significant earnings decline. Since then, the market has rapidly expanded.

Weather derivatives represent an alternative tool to the usual insurance contract by which firms and individuals can protect themselves against losing out because of unforeseen weather events. Many factors differentiate weather derivatives from insurance contracts. The main difference is due to the type of coverage provided by the two instruments. Insurance provides protection to extreme, low probability weather events, such as earthquakes, hurricanes and floods, etc. Instead, derivatives can also be used to protect the holder from all types of risks, including uncertainty in normal conditions that are much more likely to occur. This is very important for industries closely related to weather conditions for which less dramatic events can also generate huge losses.

Like other derivatives a Weather derivative is a contract between a buyer and a seller wherein the seller of a weather derivative receives a premium from a buyer with the understanding that the seller

will provide a monetary amount in case the buyer suffers any financial loss due to adverse weather conditions. In case no adverse weather condition occurs, then the seller makes a profit through the premium received.

Pricing a weather derivative is quite challenging as it cannot be stored and following issues are involved: -

- ❖ Data: - The reliability of data is a big challenge as the availability of data quite differs from one country to another and even agency to agency within a country.
- ❖ Forecasting of weather: - Though various models can be used to make short term and long-term predictions about evolving weather conditions but it is difficult to predict the future weather behaviour as it is governed by various dynamic factors. Generally, forecasts address seasonal levels but not the daily levels of temperature.
- ❖ Temperature Modelling: - Temperature is one of the important underlying for weather derivatives. The temperature normally remains quite constant across different months in a year. Hence, there is no such Model that can claim perfection and universality.

12. ELECTRICITY DERIVATIVES

The purchase and sale of power in India takes place through state-owned distribution companies which enter into Power Purchase Agreements (PPAs) with power generators. Such long-term contracts (usually around 20-25 years) are needed given the high capital and operational expenditure requirements of these projects.

Since electricity spot prices in India, are generally volatile, due to smaller market size and other various dynamic factors such as change in fuel supply positions, weather conditions, transmission congestion, variation in RE generation, and other physical attributes of production and distribution there is a need for hedging instruments that reduces price risk exposures for market participants i.e., generators, buyers and load serving entities.

As discussed earlier the derivative instruments can be used to hedge the risk of price volatility derivative contracts linked with spot electricity prices as underlying can help market participants to hedge from price risk variations. This will help the buyer to pay a fixed price irrespective of variation in spot electricity prices as variations are absorbed by derivative instruments.

Like other derivatives the vanilla forms of electricity derivatives are:

- (i) forwards,
- (ii) futures, and
- (iii) swaps.

Not only that being traded either on the exchanges or over the counters, these power contracts play the primary roles in offering future price discovery and price certainty to generators, distributing companies and other buyers.

12.1 Electricity Forwards

Electricity Forward contracts represent the obligation to buy or sell a fixed amount of electricity at a pre-specified contract price, known as the forward price, at a certain time in the future (called maturity or expiration time). Like financial and commodity forward contracts, electricity forwards are custom-tailored supply contracts between a buyer and a seller, where the buyer is obligated to take power and the seller is obligated to supply. The payoff of a forward contract promising to deliver one unit of electricity at price F at a future time T is: Payoff of a Forward Contract = $(ST - F)$; where ST is the electricity spot price at time T .

Although the payoff function appears to be similar as pay-off in case of any financial forwards, electricity forwards differ from other financial and commodity forward contracts in the sense that the underlying electricity is a different commodity at different times. The settlement price ST is usually calculated based on the average price of electricity over the delivery period at the maturity day “ T ”.

12.2 Electricity Futures

Electricity Futures are contracts for the delivery of a certain quantity of electricity at a specified price and a specified time in the future, sellers can sell a proportion of their production in the future market, while consumers can buy a specific amount of the power they need.

Like other financial futures contracts, Electricity futures contracts are standardized contracts in terms of trading locations, transaction requirements and settlement procedures. The apparent difference between the specifications of electricity futures and those of forwards is the quantity of power to be delivered. The delivery quantity specified in electricity futures contracts is often significantly smaller than that in forward contracts.

Like difference between Financial Futures and Forwards discussed earlier the electricity futures are exclusively traded on the organized exchanges and electricity forwards are usually traded over the counter. As a result, the electricity futures prices more transparent than forward prices being reflective of higher market consensus. Similar to financial futures most electricity futures contracts are settled by financial payments rather than physical delivery resulting in lowering of the transaction costs. In addition, credit risks and monitoring costs in trading futures are much lower than those in trading forwards since exchanges implement strict margin requirements to ensure the financial performance of all trading parties. The fact that the gains and losses of Electricity Futures are paid out daily, as opposed to forward contract being cumulated and paid out in a lump sum at maturity time thus reduces the credit risks. Overall, as compared to Electricity Forwards, the advantages of Electricity Futures lie in market consensus, price transparency, trading liquidity, and reduced transaction and monitoring costs though there are limitations of various basis risks associated with the rigidity in futures specification and the limited transaction quantities specified in the contracts.

12.3 Electricity Swap

Electricity Swaps are financial contracts that enable their holders to pay a fixed price for underlying electricity, regardless of the floating electricity price, or vice versa, over the contracted time. They

are typically established for a fixed quantity of power referenced to a variable spot price at either a generator's or a consumer's location. Electricity Swaps are widely used in providing short-to-medium term price certainty for up to a couple of years. Similar to financial swaps, Electricity Swap can be considered as a strip of electricity forwards with multiple settlement dates and identical forward prices for each settlement.

Another variant of Electricity Swap is Electricity Locational Basis Swaps wherein a holder of an electricity swap agrees to either pay or receive the difference between a specified futures contract price and another locational spot price of interest for a fixed constant cash flow at the time of the transaction. These swaps are used to lock-in a fixed price at a geographic location that is different from the delivery point of a futures contract and hence are effective financial instruments for hedging the risk-based on the price difference between power prices at two different physical locations.



13. DERIVATIVE MISHAPS AND LESSONS

From the above discussion it can be seen that while Derivatives can be used for hedging purpose, simultaneously they can also be used for speculation purpose also. Due to this attribute of Financial Derivatives, legendary investor Warren Buffet believes that the derivatives are financial weapons of mass destruction. Though there may be many example/cases where derivatives have proven very fatal for various organizations and even brought them to their knees, but we shall keep our discussion limited to some of infamous cases which are as follows:

13.1 Orange County's Case

This case is based on Robert Citron, the treasurer of Orange County a California municipality losing about \$ 2 billion in 1994 having a fund of about 7.5 billion. In this case Treasurer Robert Citron despite the fact having no background in trading of Financial Instrument he used derivative to speculate in Interest rates using yield curve play strategy by arbitraging the difference between long term and short-term rates that by leveraging the position of the Fund which gone very well in the years 1992 and 1993 resulting in major contributor in Income of the Orange County. Due to this reason Citron was selected even though his opponent said the strategy followed was too risky. Not only that to increase his bet on the structure of interest rate yield curve, Citron also used around \$ 2.8 billion of Inverse Floaters (a Structured Note)

Since due to type of strategy followed by Citron in 1992 and 1993 Orange County fund had been earning 300 to 400 basis points i.e. 3-4% above the returns earned by similar funds operated in the State i.e. California, Orange County Fund accepted funds from other municipalities as well. At one time Orange County's Fund stood at almost \$ 7.5 billion. Now Citron also leveraged his position in the Repo market. This practice he followed many times ultimately resulting in County's leveraged position threefold i.e. about \$ 20 billion with \$ 7.50 billion fund. Some of the municipalities realizing this over leveraged position withdrew their funds.

However, this strategy turned sour with a shift in policy of Federal Reserve in 1994, when it made first of six consecutive interest rates rise in the beginning of 1994. As a result, between February

1994 to May 1994 the County had to produce \$ 515 million in cash as Margin to cover its position. When further interest rate rise caused the fund to have a series of huge margin calls from their broker, the reserve of the County started dipping. When it could not meet margin, the lenders started selling the collateral amounting to \$ 10 Billion sending a shock wave in Bond market and prices tumbled. Not only that other bodies who invested their money with County started looking at ways to exit and started withdrawing their money lacking credible assurance. As a result of all this Citron admitted that the County had lost a fund of about \$ 1.5 Billion i.e., 20% of its value and he resigned on 3rd December 1994. Further Board of County declared County as bankrupt on 6th December 1994, to prevent move to investors to withdraw their money.

In 1996, Citron held guilty and sentence a year jail and fined \$ 1,00,000.

13.2 Barings Bank's Case

This is another infamous case of Derivative mishap. Perhaps after this mishap the term 'Operational Risk' gained importance in the world and especially in context of banking business. Further to some extent it can be said that to some extent due to this case the Basel Committee on Banking Supervision (BCBS) introduced concept of Operational risk Capital requirements in Basel II Guidelines.

This case can be considered as one of the best examples of risk that a firm could face if arbitrageur switched to speculation.

Nick Lesson, a Star trader of Barings Banks was carrying out low-risk arbitrage between the Singapore stock Exchange and Osaka Market on Nikkei 225 Futures. This arbitrage involves long position at one exchange where price of Future is bit lower and shortening position in same Futures on another exchange where prices are quite higher.

Since in some of the trade Nick Leeson incurred huge losses and to cover up these losses which can cost him his job, he started taking speculative long position on Nikkei 225 Futures on both Exchange in anticipation of price rise of same. Such action of Leeson exposed the Bank to two major risks 'Market Risk' and 'Event Risk' which can result from unexpected major events though may not be directly related to market.

Leeson in addition to being Floor's manager was also in charge of back office i.e., settlement operations, which allowed him to influence the staff of back office to hide losses due to trading positions taken by him. To hide these losses, he used an old error account '8888'. Not only that by hiding these losses, but he was also able to show a substantial profit in 1994 for which he was rewarded with a bonus of \$ 7,20,000.

To some extent it can also be termed as an oversight by management when in 1994, Leeson asked for \$ 354 million for margin call which he received without any question, as management was of view that Leeson is using a risk-free strategy.

In January 1995 guessing that both Singapore and Tokyo stock exchanges would remain stable as neither going down or up Leeson built-up Future positions on both exchanges with a total notional

value of \$ 7 Billion on Nikkei 225. In addition to that he also started selling Futures on Long-Term and Short-Term Japanese Government Bond. The main reason for this strategy was that interest rate moves in opposite direction of the price of debt. This position would be profit if there is a rise in interest rates on these Bonds. Unfortunately, due to a big earthquake in Japan on 17 January 1995 both Japanese Stock Market and Interest Rate plunged resulting in huge losses of \$ 827 million (\$ 1.4 Billion) in both positions taken by Nick Leeson.

On 23rd February 1995, Nick left Singapore and on next day the management of Barings Bank were informed about the situation. To meet the requirement of funds for liquidation position on both exchanges the 233 years old bank became bankrupt and in March 1995, ING a Dutch Bank purchased this Bank for £1 only.

13.3 Protector & Gamble (P&G) and Gibson Greetings' Case

This is a dramatic example of activities of Banker Trust (BT) a banking organization who in 1994 intentionally developed complex derivative structures product and sold them to various clients including P&G and Gibson Greetings leading to huge losses for these two companies. Further it also misled both companies into thinking that the products have been structured to meet their individual needs. The products sold to these two companies were inappropriate because BT was aware of the risk appetite of these companies and other clients. As a result, both the companies sued BT and it was forced to pay a huge amount to them for settlement made out of court.

In 1999 this banking organization was taken over by Deutsche Bank.

This case supports the thumb rule that if a product is so complex and complicated that it cannot be understood by the client it should not be offered or sold to the same.

In this case BT sold Leveraged Swap products to the P&G. A Leveraged Swap (also known Ratio Swap or Power Swap) is just like plain vanilla swap with the difference that the receipt/payments are adjusted by a multiplying factor or leverage factor. The result is that magnifying effect because of compounding with interest rate movement.

The structure of the deal was such that P&G could make a profit if there is no change in rates of returns on the two Bonds or if the rates of return did not increase to the point where the spread has a positive value. Though the profit to P&G was limited to 0.75% per 6 months, the potential loss was unlimited or without ceiling because of the rise in rate of return on the Bonds.

In similar manner the Banker's Trust sold two swap products 'Ratio Swap' and 'Basis Swap' to Gibson Greetings (an American manufacturer of cards and wrapping papers) in 1992. Under this agreement Gibson in exchange of receiving 5.5% from BT agreed to pay floating rate squared and then divided by 6. Though this swap was a good bet in a declining interest environment. However, if interest LIBOR rises beyond a certain point, then it will give a loss and it would increase exponentially. As a result of this swap agreement the Gibson Greetings suffered a loss of \$ 3 Million in February 1994, as interest rates are increased because FRR tightened the monetary policy.

Further in April 1994, it suffered a loss of \$ 16.7 Million at the same time P&G suffered a loss of \$ 106 million from the swap agreement.

Both P&G and Gibson Greetings filed suit against BT and reached an out of court settlement with both.

13.4 Lessons from Derivative Mishaps

Following are some of the important lessons can be learnt from the above-mentioned case studies of Derivative Mishaps.

13.4.1 Don't buy any derivative product that you don't understand

This is an important lesson for non-financial corporation not to undertake a trade or derivative product that they do not understand. As apparent in above mentioned case of Orange County, treasurer Robert Citron speculated on derivative instruments even though he has no financial background. Similar things happened in BT's case where both P&G and Gibson Greetings were misguided.

The best way to avoid such loss is to value the instrument in house because outside persons can misguide the corporation about the potential dangers.

13.4.2 Due diligence before making Treasury Department as a Profit Centre

Though the main objective of establishing a Treasury Department is to reduce financing costs and manage risk optimally. But it has been seen that though initially Treasury Department made limited profits from treasury activities later started taking more risks in anticipation of higher profit. As mentioned in case study of Orange County the treasurer Citron with initial profit from yield curve play strategy leveraged its position and led to bankruptcy. The best way to avoid this situation is to avoid linking the treasurer's salary with the profit he made for the organization.

13.4.3 Specify the Risk Limits

Proper monitoring is prerequisite for the trader to ensure that he/she should switch from arbitrageur to speculator. Above mentioned Baring Bank's case is a leading example for the bankruptcy of same bank as his positions remained unmonitored and unquestionable by the management.

The best way to avoid the situation of overtrading is to limit the sizes positions that can be taken by a trader, and it should be accurately reported from risk perspective. The management should ensure that the limits specified should be strictly obeyed and even daily reports of various positions taken by each trader (though a star performer) should be obtained and scrutinized before the things goes out of control.

13.4.4 Separation of Front, Middle and Back Offices

The three offices though are interlinked but they discharge separate functions. Accordingly, there should be a firewall in the functioning of these offices i.e. person of one office should not have the access to the functioning of other office. Barings bank's case is a classic example where Nick Leeson

carried out manipulations in back office (which was under his control also) and hid the losses in error account.

To ensure that these three offices work independently it is essential that role and functions of each office should be clearly defined and followed.

13.4.5 Ensure that a hedger should not become a speculator

In most of the cases discussed above hedgers/arbitrageur have become speculators and leveraged their position.

To avoid this situation, it is essential that clear cut risk limits should be defined. Further before entering into any trading strategy proper risk analysis should be carried out and if proposed strategy is crossing the limits of Risk Appetite of the company it should be avoided.

13.4.6 Carry out Stress Test, Scenario Analysis etc.

As mentioned in above case of BT where Gibson Greetings was of belief that the interest rates shall remain lower and to some extent ignored the possibility of increasing of interest rates by 1%. But it happened and ultimately Gibson Greetings faced a huge loss.

To counter this type of unpredictable situation it is necessary that VAR analysis should always be followed by Scenario Analysis because as tendency a human being normally can anticipate two to three scenarios. It will be better to refer the data of at least 10 to 20 years to anticipate a Black Swan event.

Further even Simulation Test can be applied to analyze the results in various possible situations.

TEST YOUR KNOWLEDGE

Theoretical Questions

1. What are the reasons for stock index futures becoming more popular financial derivatives over stock futures segment in India?
2. Write short note on Marking to market.
3. State any four assumptions of Black Scholes Model.
4. Define the term Greeks with respect to options.

Practical Questions

1. The 6-months forward price of a security is ₹ 208.18. The borrowing rate is 8% per annum payable with monthly rests. What should be the spot price?
2. The following data relate to Anand Ltd.'s share price:

Current price per share	₹ 1,800
6 months future's price/share	₹ 1,950

Assuming it is possible to borrow money in the market for transactions in securities at 12% per annum, you are required:

- (i) to calculate the theoretical minimum price of a 6-months forward purchase; and
 - (ii) to explain arbitrage opportunity.
3. On 31-8-2011, the value of stock index was ₹ 2,200. The risk-free rate of return has been 8% per annum. The dividend yield on this Stock Index is as under:

Month	Dividend Paid p.a.
January	3%
February	4%
March	3%
April	3%
May	4%
June	3%
July	3%
August	4%
September	3%
October	3%
November	4%
December	3%

Assuming that interest is continuously compounded daily, find out the future price of contract deliverable on 31-12-2011. Given: $e^{0.01583} = 1.01593$

4. Calculate the price of 3 months PQR futures, if PQR (FV ₹10) quotes ₹220 on NSE and the three months future price quotes at ₹230 and the one month borrowing rate is given as 15 percent per annum and the expected annual dividend is 25 percent, payable before expiry. Also examine arbitrage opportunities.
- 5.

BSE	5000
Value of portfolio	₹ 10,10,000
Risk free interest rate	9% p.a.
Dividend yield on Index	6% p.a.
Beta of portfolio	1.5

We assume that a future contract on the BSE index with four months maturity is used to hedge the value of portfolio over next three months. One future contract is for delivery of 50 times the index.

Based on the above information calculate:

- (i) Price of future contract.
 - (ii) The gain on short futures position if index turns out to be 4,500 in three months.
6. The share of X Ltd. is currently selling for ₹ 300. Risk free interest rate is 0.8% per month. A three-month futures contract is selling for ₹ 312. Develop an arbitrage strategy and show what your riskless profit will be 3 months hence assuming that X Ltd. will not pay any dividend in the next three months.

7. A Mutual Fund is holding the following assets in ₹ Crores :

Investments in diversified equity shares	90.00
Cash and Bank Balances	<u>10.00</u>
	100.00

The Beta of the equity shares portfolio is 1.1. The index future is selling at 4300 level. The Fund Manager apprehends that the index will fall at the most by 10%. How many index futures he should short for perfect hedging? One index future consists of 50 units.

Substantiate your answer assuming the Fund Manager's apprehension will materialize.

8. A trader is having in its portfolio shares worth ₹ 85 lakhs at current price and cash ₹ 15 lakhs. The beta of share portfolio is 1.6. After 3 months the price of shares dropped by 3.2%.

Determine:

- (i) Current portfolio beta
 - (ii) Portfolio beta after 3 months if the trader on current date goes for long position on ₹ 100 lakhs Nifty futures.
9. Which position on the index future gives a speculator, a complete hedge against the following transactions:
- (i) The share of Right Limited is going to rise. He has a long position on the cash market of ₹ 50 lakhs on the Right Limited. The beta of the Right Limited is 1.25.
 - (ii) The share of Wrong Limited is going to depreciate. He has a short position on the cash market of ₹ 25 lakhs on the Wrong Limited. The beta of the Wrong Limited is 0.90.
 - (iii) The share of Fair Limited is going to stagnant. He has a short position on the cash market of ₹ 20 lakhs of the Fair Limited. The beta of the Fair Limited is 0.75.
10. Ram buys 10,000 shares of X Ltd. at a price of ₹ 22 per share whose beta value is 1.5 and sells 5,000 shares of A Ltd. at a price of ₹ 40 per share having a beta value of 2. He obtains a complete hedge by Nifty futures at ₹ 1,000 each. He closes out his position at the closing price of the next day when the share of X Ltd. dropped by 2%, share of A Ltd. appreciated by 3% and Nifty futures dropped by 1.5%.

What is the overall profit/loss to Ram?

11. On January 1, 2013 an investor has a portfolio of 5 shares as given below:

Security	Price	No. of Shares	Beta
A	349.30	5,000	1.15
B	480.50	7,000	0.40
C	593.52	8,000	0.90
D	734.70	10,000	0.95
E	824.85	2,000	0.85

The cost of capital to the investor is 10.5% per annum.

You are required to calculate:

- The beta of his portfolio.
- The theoretical value of the NIFTY futures for February 2013.
- The number of contracts of NIFTY the investor needs to sell to get a full hedge until February for his portfolio if the current value of NIFTY is 5900 and NIFTY futures have a minimum trade lot requirement of 200 units. Assume that the futures are trading at their fair value.
- The number of future contracts the investor should trade if he desires to reduce the beta of his portfolios to 0.6.

No. of days in a year be treated as 365.

Given: $\ln(1.105) = 0.0998$ and $e^{(0.015858)} = 1.01598$

12. Details about portfolio of shares of an investor is as below:

Shares	No. of shares (lakh)	Price per share	Beta
A Ltd.	3.00	₹ 500	1.40
B Ltd.	4.00	₹ 750	1.20
C Ltd.	2.00	₹ 250	1.60

The investor thinks that the risk of portfolio is very high and wants to reduce the portfolio beta to 0.91. He is considering two below mentioned alternative strategies:

- Dispose off a part of his existing portfolio to acquire risk free securities, or
- Take appropriate position on Nifty Futures which are currently traded at 8125 and each Nifty points is worth ₹ 200.

You are required to determine:

- (1) portfolio beta,
- (2) the value of risk free securities to be acquired,
- (3) the number of shares of each company to be disposed off,
- (4) the number of Nifty contracts to be bought/sold; and
- (5) the value of portfolio beta for 2% rise in Nifty.

13. On April 1, 2015, an investor has a portfolio consisting of eight securities as shown below:

Security	Market Price	No. of Shares	Value
A	29.40	400	0.59
B	318.70	800	1.32
C	660.20	150	0.87
D	5.20	300	0.35
E	281.90	400	1.16
F	275.40	750	1.24
G	514.60	300	1.05
H	170.50	900	0.76

The cost of capital for the investor is 20% p.a. continuously compounded. The investor fears a fall in the prices of the shares in the near future. Accordingly, he approaches you for the advice to protect the interest of his portfolio.

You can make use of the following information:

- (1) The current NIFTY value is 8500.
- (2) NIFTY futures can be traded in units of 25 only.
- (3) Futures for May are currently quoted at 8700 and Futures for June are being quoted at 8850.

You are required to calculate:

- (i) the beta of his portfolio.
- (ii) the theoretical value of the futures contract for contracts expiring in May and June.

Given ($e^{0.03}=1.03045$, $e^{0.04}=1.04081$, $e^{0.05}=1.05127$)

- (iii) the number of NIFTY contracts that he would have to sell if he desires to hedge until June in each of the following cases:
- (A) His total portfolio
 - (B) 50% of his portfolio
 - (C) 120% of his portfolio
14. Sensex futures are traded at a multiple of 50. Consider the following quotations of Sensex futures in the 10 trading days during February, 2009:

<u>Day</u>	<u>High</u>	<u>Low</u>	<u>Closing</u>
4-2-09	3306.4	3290.00	3296.50
5-2-09	3298.00	3262.50	3294.40
6-2-09	3256.20	3227.00	3230.40
7-2-09	3233.00	3201.50	3212.30
10-2-09	3281.50	3256.00	3267.50
11-2-09	3283.50	3260.00	3263.80
12-2-09	3315.00	3286.30	3292.00
14-2-09	3315.00	3257.10	3309.30
17-2-09	3278.00	3249.50	3257.80
18-2-09	3118.00	3091.40	3102.60

Abshishek bought one sensex futures contract on February, 04. The average daily absolute change in the value of contract is ₹ 10,000 and standard deviation of these changes is ₹ 2,000. The maintenance margin is 75% of initial margin.

You are required to determine the daily balances in the margin account and payment on margin calls, if any.

15. Mr. A purchased a 3 month call option for 100 shares in XYZ Ltd. at a premium of ₹ 30 per share, with an exercise price of ₹ 550. He also purchased a 3 month put option for 100 shares of the same company at a premium of ₹ 5 per share with an exercise price of ₹ 450. The market price of the share on the date of Mr. A's purchase of options, is ₹ 500. Calculate the profit or loss that Mr. A would make assuming that the market price falls to ₹ 350 at the end of 3 months.
16. The market received rumour about ABC corporation's tie-up with a multinational company. This has induced the market price to move up. If the rumour is false, the ABC corporation stock price will probably fall dramatically. To protect from this an investor has bought the call and put options.

He purchased one 3 months call with a striking price of ₹ 42 for ₹ 2 premium, and paid Re.1 per share premium for a 3 months put with a striking price of ₹ 40.

- (i) Determine the Investor's position if the tie up offer bids the price of ABC Corporation's stock up to ₹ 43 in 3 months.
- (ii) Determine the Investor's ending position, if the tie up programme fails and the price of the stocks falls to ₹ 36 in 3 months.

17. Equity share of PQR Ltd. is presently quoted at ₹ 320. The Market Price of the share after 6 months has the following probability distribution:

Market Price	₹ 180	260	280	320	400
Probability	0.1	0.2	0.5	0.1	0.1

A put option with a strike price of ₹ 300 can be written.

You are required to find out expected value of option at maturity (i.e. 6 months)

18. You as an investor had purchased a 4 month call option on the equity shares of X Ltd. of ₹ 10, of which the current market price is ₹ 132 and the exercise price ₹ 150. You expect the price to range between ₹ 120 to ₹ 190. The expected share price of X Ltd. and related probability is given below:

Expected Price (₹)	120	140	160	180	190
Probability	0.05	0.20	0.50	0.10	0.15

Compute the following:

- (i) Expected Share price at the end of 4 months.
 - (ii) Value of Call Option at the end of 4 months, if the exercise price prevails.
 - (iii) In case the option is held to its maturity, what will be the expected value of the call option?
19. Mr. X established the following strategy on the Delta Corporation's stock :
- (1) Purchased one 3-month call option with a premium of ₹ 30 and an exercise price of ₹ 550.
 - (2) Purchased one 3-month put option with a premium of ₹ 5 and an exercise price of ₹ 450.
- Delta Corporation's stock is currently selling at ₹ 500. Determine profit or loss, if the price of Delta Corporation's stock:
- (i) remains at ₹ 500 after 3 months.
 - (ii) falls at ₹ 350 after 3 months.

(iii) rises to ₹ 600.

Assume the option size is 100 shares of Delta Corporation.

20. The equity share of VCC Ltd. is quoted at ₹ 210. A 3-month call option is available at a premium of ₹ 6 per share and a 3-month put option is available at a premium of ₹ 5 per share. Ascertain the net payoffs to the option holder of a call option and a put option separately.

(i) the strike price in both cases in ₹ 220; and

(ii) the share price on the exercise day is ₹ 200, 210, 220, 230, 240.

Also indicate the price range at which the call and the put options may be gainfully exercised.

21. Sumana wanted to buy shares of EIL which has a range of ₹ 411 to ₹ 592 a month later. The present price per share is ₹ 421. Her broker informs her that the price of this share can sore up to ₹ 522 within a month or so, so that she should buy a one-month CALL of EIL. In order to be prudent in buying the call, the share price should be more than or at least ₹ 522 the assurance of which could not be given by her broker.

Though she understands the uncertainty of the market, she wants to know the probability of attaining the share price ₹ 592 so that buying of a one-month CALL of EIL at the execution price of ₹ 522 is justified. Advice her. Take the risk-free interest to be 3.60% for one month and $e^{0.036} = 1.037$.

22. Mr. Dayal is interested in purchasing equity shares of ABC Ltd. which are currently selling at ₹ 600 each. He expects that price of share may go upto ₹ 780 or may go down to ₹ 480 in three months. The chances of occurring such variations are 60% and 40% respectively. A call option on the shares of ABC Ltd. can be exercised at the end of three months with a strike price of ₹ 630.

(i) What combination of share and option should Mr. Dayal select if he wants a perfect hedge?

(ii) What should be the value of option today (the risk free rate is 10% p.a.)?

(iii) What is the expected rate of return on the option?

23. Consider a two-year call option with a strike price of ₹ 50 on a stock the current price of which is also ₹ 50. Assume that there are two-time periods of one year and in each year the stock price can move up or down by equal percentage of 20%. The risk-free interest rate is 6%. Using binominal option model, calculate the probability of price moving up and down. Also draw a two-step binomial tree showing prices and payoffs at each node.

24. The current market price of an equity share of Penchant Ltd is ₹ 420. Within a period of 3 months, the maximum and minimum price of it is expected to be ₹ 500 and ₹ 400 respectively. If the risk free rate of interest be 8% p.a., what should be the value of a 3 months Call option under the "Risk Neutral" method at the strike rate of ₹ 450?

Given $e^{0.02} = 1.0202$

25. From the following data for certain stock, find the value of a call option:

Price of stock now	= ₹ 80
Exercise price	= ₹ 75
Standard deviation of continuously compounded annual return	= 0.40
Maturity period	= 6 months
Annual interest rate	= 12%

Given

Number of S.D. from Mean, (z)	Area of the left or right (one tail)
0.25	0.4013
0.30	0.3821
0.55	0.2912
0.60	0.2743

$$e^{0.12 \times 0.5} = 1.062$$

$$\ln 1.0667 = 0.0646$$

ANSWERS/ SOLUTIONS

Answers to Theoretical Questions

1. Please refer paragraph 5.2.4.
2. Please refer paragraph 5.2.3.
3. Please refer paragraph 7.3.
4. Please refer paragraph 7.4.

Answers to the Practical Questions

1. Calculation of spot price

The formula for calculating forward price is:

$$A = P \left(1 + \frac{r}{n}\right)^{nt}$$

Where

- A = Forward price
- P = Spot Price
- r = rate of interest
- n = no. of compounding
- t = time

Using the above formula,

$$208.18 = P (1 + 0.08/12)^6$$

$$\text{Or } 208.18 = P \times 1.0409$$

$$P = 208.18/1.0409 = 200$$

Hence, the spot price should be ₹ 200.

2. Anand Ltd

(i) Calculation of theoretical minimum price of a 6 months forward contract-

$$\text{Theoretical minimum price} = ₹ 1,800 + (₹ 1,800 \times 12/100 \times 6/12) = ₹ 1,908$$

(ii) Arbitrage Opportunity-

The arbitrageur can borrow money @ 12 % for 6 months and buy the shares at ₹ 1,800. At the same time he can sell the shares in the futures market at ₹ 1,950. On the expiry date 6 months later, he could deliver the share and collect ₹ 1,950 pay off ₹ 1,908 and record a profit of ₹ 42 (₹ 1,950 – ₹ 1,908)

3. The duration of future contract is 4 months. The average yield during this period will be:

$$\frac{3\% + 3\% + 4\% + 3\%}{4} = 3.25\%$$

As per Cost to Carry model the future price will be

$$F = S e^{(r_f - D)t}$$

Where S = Spot Price

r_f = Risk Free interest

D = Dividend Yield

t = Time Period

Accordingly, future price will be

$$\begin{aligned} &= ₹ 2,200 e^{(0.08 - 0.0325) \times 4/12} = ₹ 2,200 e^{0.01583} \\ &= ₹ 2,200 \times 1.01593 = ₹ 2235.05 \end{aligned}$$

4. Future's Price = Spot + cost of carry – Dividend

$$F = 220 + 220 \times (0.15 \times 0.25)^{\dagger} - 0.25^{**} \times 10 = 225.75$$

** Entire 25% dividend is payable before expiry, which is ₹2.50.

† Alternatively monthly compounding can also be used.

Thus, we see that futures price by calculation is ₹225.75 which is quoted at ₹230 in the exchange.

(i) Analysis:

Fair value of Futures less than Actual futures Price:

Futures Overvalued Hence it is advised to sell. Also do Arbitraging by buying stock in the cash market.

Step I

He will buy PQR Stock at ₹220 by borrowing at 15% for 3 months. Therefore, his outflows are:

Cost of Stock	220.00
Add: Interest @ 15 % for 3 months i.e. 0.25 years $(220 \times 0.15 \times 0.25)$	<u>8.25</u>
Total Outflows (A)	<u>228.25</u>

Step II

He will sell March 2000 futures at ₹230. Meanwhile he would receive dividend for his stock.

Hence his inflows are	230.00
Sale proceeds of March 2000 futures	<u>2.50</u>
Total inflows (B)	<u>232.50</u>

Inflow – Outflow = Profit earned by Arbitrageur

$$= 232.50 - 228.25 = 4.25$$

5. (i) Current future price of the index = $5000 + 5000 (0.09-0.06) \frac{4}{12} = 5000 + 50 = 5,050$

$$\therefore \text{Price of the future contract} = ₹ 50 \times 5,050 = ₹ 2,52,500$$

(ii) Hedge ratio = $\frac{1010000}{252500} \times 1.5 = 6 \text{ contracts}$

Index after three months turns out to be 4500

$$\text{Future price will be} = 4500 + 4500 (0.09-0.06) \times \frac{1}{12} = 4,511.25$$

$$\begin{aligned} \text{Therefore, Gain from the short futures position is} &= 6 \times (5050 - 4511.25) \times 50 \\ &= ₹1,61,625 \end{aligned}$$

Note: Alternatively we can also use daily compounding (exponential) formula.

6. The appropriate value of the 3 months futures contract is –

$$F_0 = ₹ 300 (1.008)^3 = ₹ 307.26$$

Since the futures price exceeds its appropriate value it pays to do the following:-

Action	Initial Cash flow	Cash flow at time T (3 months)
Borrow ₹ 300 now and repay with interest after 3 months	+ ₹ 300	- ₹ 300 (1.008) ³ = - ₹ 307.26
Buy a share	- ₹ 300	ST
Sell a futures contract (Fo = 312/-)	0	₹ 312 – ST
Total	₹ 0	₹ 4.74

Such an action would produce a risk less profit of ₹ 4.74.

7. Number of index future to be sold by the Fund Manager is:

$$\frac{1.1 \times 90,00,00,000}{4,300 \times 50} = 4,605$$

Justification of the answer:

$$\text{Loss in the value of the portfolio if the index falls by 10\% is } ₹ \frac{11}{100} \times 90 \text{ Crore} = ₹ 9.90$$

Crore.

$$\text{Gain by short covering of index future is: } \frac{0.1 \times 4,300 \times 50 \times 4,605}{1,00,00,000} = 9.90 \text{ Crore}$$

This justifies the answer. Further, cash is not a part of the portfolio.

8. (i) **Current Portfolio Beta**

$$\text{Current Beta for share portfolio} = 1.6$$

$$\text{Beta for cash} = 0$$

$$\text{Current portfolio beta} = 0.85 \times 1.6 + 0 \times 0.15 = 1.36$$

- (ii) **Portfolio beta after 3 months:**

$$\text{Beta for portfolio of shares} = \frac{\text{Change in value of portfolio of share}}{\text{Change in value of market portfolio (Index)}}$$

$$1.6 = \frac{0.032}{\text{Change in value of market portfolio (Index)}}$$

$$\text{Change in value of market portfolio (Index)} = (0.032 / 1.6) \times 100 = 2\%$$

Position taken on 100 lakh Nifty futures : Long

$$\begin{aligned}\text{Value of index after 3 months} &= ₹ 100 \text{ lakh} \times (1.00 - 0.02) \\ &= ₹ 98 \text{ lakh}\end{aligned}$$

$$\text{Mark-to-market paid} = ₹ 2 \text{ lakh}$$

$$\text{Cash balance after payment of mark-to-market} = ₹ 13 \text{ lakh}$$

$$\begin{aligned}\text{Value of portfolio after 3 months} &= ₹ 85 \text{ lakh} \times (1 - 0.032) + ₹ 13 \text{ lakh} \\ &= ₹ 95.28 \text{ lakh}\end{aligned}$$

$$\text{Change in value of portfolio} = \frac{₹ 100 \text{ lakh} - ₹ 95.28 \text{ lakh}}{₹ 100 \text{ lakh}} = 4.72\%$$

$$\text{Portfolio beta} = 0.0472/0.02 = 2.36$$

9.

Sl. No. (1)	Company Name (2)	Trend (3)	Amount (₹) (4)	Beta (5)	(₹) (6) [(4) x (5)]	Position (7)
(i)	Right Ltd.	Rise	50 lakh	1.25	62,50,000	Short
(ii)	Wrong Ltd.	Depreciate	25 lakh	0.90	22,50,000	Long
(iii)	Fair Ltd.	Stagnant	20 lakh	0.75	15,00,000	Long
					25,00,000	Short

10. No. of the Future Contract to be obtained to get a complete hedge

$$\begin{aligned}&= \frac{10000 \times ₹ 22 \times 1.5 - 5000 \times ₹ 40 \times 2}{₹ 1000} \\ &= \frac{₹ 3,30,000 - ₹ 4,00,000}{₹ 1000} = 70 \text{ contracts}\end{aligned}$$

Thus, by purchasing 70 Nifty future contracts to be long to obtain a complete hedge.

Cash Outlay

$$\begin{aligned}&= 10000 \times ₹ 22 - 5000 \times ₹ 40 + 70 \times ₹ 1,000 \\ &= ₹ 2,20,000 - ₹ 2,00,000 + ₹ 70,000 = ₹ 90,000\end{aligned}$$

Cash Inflow at Close Out

$$\begin{aligned}&= 10000 \times ₹ 22 \times 0.98 - 5000 \times ₹ 40 \times 1.03 + 70 \times ₹ 1,000 \times 0.985 \\ &= ₹ 2,15,600 - ₹ 2,06,000 + ₹ 68,950 = ₹ 78,550\end{aligned}$$

Gain/ Loss

$$= ₹ 78,550 - ₹ 90,000 = - ₹ 11,450 \text{ (Loss)}$$

11. (i) **Calculation of Portfolio Beta**

Security	Price of the Stock	No. of shares	Value	Weightage w_i	Beta B_i	Weighted Beta
A	349.30	5,000	17,46,500	0.093	1.15	0.107
B	480.50	7,000	33,63,500	0.178	0.40	0.071
C	593.52	8,000	47,48,160	0.252	0.90	0.227
D	734.70	10,000	73,47,000	0.390	0.95	0.370
E	824.85	2,000	16,49,700	0.087	0.85	0.074
			1,88,54,860			0.849

Portfolio Beta = 0.849

(ii) **Calculation of Theoretical Value of Future Contract**

Cost of Capital = 10.5% p.a. Accordingly, the Continuously Compounded Rate of Interest $\ln(1.105) = 0.0998$

For February 2013 contract, $t = 58/365 = 0.1589$

$$\text{Further } F = S e^{rt}$$

$$F = ₹ 5,900 e^{(0.0998)(0.1589)}$$

$$F = ₹ 5,900 e^{0.015858}$$

$$F = ₹ 5,900 \times 1.01598 = ₹ 5,994.28$$

Alternatively, it can also be taken as follows:

$$= ₹ 5900 e^{0.105 \times 58/365}$$

$$= ₹ 5900 e^{0.01668}$$

$$= ₹ 5900 \times 1.01682 = ₹ 5,999.24$$

(iii) **When total portfolio is to be hedged:**

$$= \frac{\text{Value of Spot Position requiring hedging}}{\text{Value of Future Contract}} \times \text{Portfolio Beta}$$

$$= \frac{1,88,54,860}{5994.28 \times 200} \times 0.849 = 13.35 \text{ contracts say 13 or 14 contracts}$$

(iv) **When total portfolio beta is to be reduced to 0.6:**

$$\begin{aligned} \text{Number of Contracts to be sold} &= \frac{P(\beta_P - \beta'_P)}{F} \\ &= \frac{1,88,54,860(0.849 - 0.600)}{5994.28 \times 200} = 3.92 \text{ contracts say 4 contracts} \end{aligned}$$

12.

Shares	No. of shares (lakhs) (1)	Market Price of Per Share (2)	× (2) (₹ lakhs)	% to total (w)	β (x)	wx
A Ltd.	3.00	500.00	1500.00	0.30	1.40	0.42
B Ltd.	4.00	750.00	3000.00	0.60	1.20	0.72
C Ltd.	2.00	250.00	<u>500.00</u>	<u>0.10</u>	1.60	<u>0.16</u>
			<u>5000.00</u>	1.00		<u>1.30</u>

(1) Portfolio beta 1.30

(2) Required Beta 0.91

Let the proportion of risk free securities for target beta $0.91 = p$

$$0.91 = 0 \times p + 1.30 (1 - p)$$

$$p = 0.30 \text{ i.e. } 30\%$$

Shares to be disposed off to reduce beta ($5000 \times 30\%$) ₹ 1,500 lakh and Risk Free securities to be acquired.

(3) Number of shares of each company to be disposed off

Shares	% to total (w)	Proportionate Amount (₹ lakhs)	Market Price Per Share	No. of Shares (Lakh)
A Ltd.	0.30	450.00	500.00	0.90
B Ltd.	0.60	900.00	750.00	1.20
C Ltd.	0.10	150.00	250.00	0.60

(4) Number of Nifty Contract to be sold

$$\frac{(1.30 - 0.91) \times 5000 \text{ lakh}}{8,125 \times 200} = 120 \text{ contracts}$$

- (5) 2% rises in Nifty is accompanied by $2\% \times 1.30$ i.e. 2.6% rise for portfolio of shares

	₹ Lakh
Current Value of Portfolio of Shares	5000
Value of Portfolio after rise	5130
Mark-to-Market Margin paid $(8125 \times 0.020 \times ₹ 200 \times 120)$	39
Value of the portfolio after rise of Nifty	5091
% change in value of portfolio $(5091 - 5000) / 5000$	1.82%
% rise in the value of Nifty	2%
Beta	0.91

13. (i) **Beta of the Portfolio**

Security	Market Price	No. of Shares	Value	β	Value $\times \beta$
A	29.40	400	11760	0.59	6938.40
B	318.70	800	254960	1.32	336547.20
C	660.20	150	99030	0.87	86156.10
D	5.20	300	1560	0.35	546.00
E	281.90	400	112760	1.16	130801.60
F	275.40	750	206550	1.24	256122.00
G	514.60	300	154380	1.05	162099.00
H	170.50	900	153450	0.76	116622.00
			994450		1095832.30

$$\text{Portfolio Beta} = \frac{10,95,832.30}{9,94,450} = 1.102$$

(ii) **Theoretical Value of Future Contract Expiring in May and June**

$$F = Se^{rt}$$

$$F_{\text{May}} = 8500 \times e^{0.20 \times (2/12)} = 8500 \times e^{0.0333}$$

$e^{0.0333}$ shall be computed using Interpolation Formula as follows:

$e^{0.03}$	= 1.03045
$e^{0.04}$	= 1.04081
$e^{0.01}$	= 0.01036

$e^{0.0033}$	= 0.00342
$e^{0.0067}$	= 0.00694

$$e^{0.0333} = 1.03045 + 0.00342 = 1.03387 \text{ or } 1.04081 - 0.00694 = 1.03387$$

According the price of the May Contract

$$8500 \times 1.03387 = ₹ 8788$$

Price of the June Contract

$$F_{\text{May}} = 8500 \times e^{0.20 \times (3/12)} = 8500 \times e^{0.05} = 8500 \times 1.05127 = 8935.80$$

(iii) **No. of NIFTY Contracts required to sell to hedge until June**

$$= \frac{\text{Value of Position to be hedged}}{\text{Value of Future Contract}} \times \beta$$

(A) Total portfolio

$$\frac{994450}{8850 \times 25} \times 1.102 = 4.953 \text{ say 5 contracts}$$

(B) 50% of Portfolio

$$\frac{994450 \times 0.50}{8850 \times 25} \times 1.102 = 2.47 \text{ say 3 contracts}$$

(C) 120% of Portfolio

$$\frac{994450 \times 1.20}{8850 \times 25} \times 1.102 = 5.94 \text{ say 6 contracts}$$

14. Initial Margin = $\mu + 3\sigma$

Where μ = Daily Absolute Change

σ = Standard Deviation

Accordingly

$$\text{Initial Margin} = ₹ 10,000 + ₹ 6,000 = ₹ 16,000$$

$$\text{Maintenance margin} = ₹ 16,000 \times 0.75 = ₹ 12,000$$

Day	Changes in future Values (₹)	Margin A/c (₹)	Call Money (₹)
4/2/09	-	16000	-
5/2/09	$50 \times (3294.40 - 3296.50) = -105$	15895	-
6/2/09	$50 \times (3230.40 - 3294.40) = -3200$	12695	-
7/2/09	$50 \times (3212.30 - 3230.40) = -905$	16000	4210

10/2/09	$50 \times (3267.50 - 3212.30) = 2760$	18760	-
11/2/09	$50 \times (3263.80 - 3267.50) = -185$	18575	-
12/2/09	$50 \times (3292 - 3263.80) = 1410$	19985	-
14/2/09	$50 \times (3309.30 - 3292) = 865$	20850	-
17/2/09	$50 \times (3257.80 - 3309.30) = -2575$	18275	-
18/2/09	$50 \times (3102.60 - 3257.80) = -7760$	16000	5485

15. Since the market price at the end of 3 months falls to ₹ 350 which is below the exercise price under the call option, the call option will not be exercised. Only put option becomes viable.

	₹
The gain will be:	
Gain per share (₹450 – ₹ 350)	<u>100</u>
Total gain per 100 shares	10,000
Cost or premium paid (₹ 30 x 100) + (₹ 5 x 100)	<u>3,500</u>
Net gain	<u>6,500</u>

16. Cost of Call and Put Options

$$= (\text{₹ } 2 \text{ per share}) \times (100 \text{ share call}) + (\text{₹ } 1 \text{ per share}) \times (100 \text{ share put})$$

$$= \text{₹ } 2 \times 100 + 1 \times 100$$

$$= \text{₹ } 300$$

- (i) Price increases to ₹43. Since the market price is higher than the strike price of the call, the investor will exercise it.

$$\begin{aligned} \text{Ending position} &= (- \text{₹ } 300 \text{ cost of 2 option}) + (\text{₹ } 1 \text{ per share gain on call}) \times 100 \\ &= - \text{₹ } 300 + 100 \end{aligned}$$

$$\text{Net Loss} = - \text{₹ } 200$$

- (ii) The price of the stock falls to ₹36. Since the market price is lower than the strike price, the investor may not exercise the call option.

$$\begin{aligned} \text{Ending Position} &= (- \text{₹ } 300 \text{ cost of 2 options}) + (\text{₹ } 4 \text{ per stock gain on put}) \times 100 \\ &= - \text{₹ } 300 + 400 \end{aligned}$$

$$\text{Gain} = \text{₹ } 100$$

17. Expected Value of Option

$$(300 - 180) \times 0.1 \quad 12$$

$$(300 - 260) \times 0.2 \quad 8$$

$(300 - 280) \times 0.5$	10
$(300 - 320) \times 0.1$	Not Exercised*
$(300 - 400) \times 0.1$	<u>Not Exercised*</u>
	<u>30</u>

* If the strike price goes beyond ₹ 300, option is not exercised at all.

In case of Put option, since Share price is greater than strike price Option Value would be zero.

18. (i) Expected Share Price

$$= ₹120 \times 0.05 + ₹140 \times 0.20 + ₹160 \times 0.50 + ₹180 \times 0.10 + ₹190 \times 0.15$$

$$= ₹6 + ₹28 + ₹80 + ₹18 + ₹28.50 = ₹160.50$$

(ii) Value of Call Option

$$= ₹150 - ₹150 = \text{Nil}$$

(iii) If the option is held till maturity the expected Value of Call Option

Expected price (X)	Value of call (C)	Probability (P)	CP
₹ 120	0	0.05	0
₹ 140	0	0.20	0
₹ 160	₹ 10	0.50	₹ 5
₹ 180	₹ 30	0.10	₹ 3
₹ 190	₹ 40	0.15	<u>₹ 6</u>
Total			<u>₹ 14</u>

Alternatively, it can also be calculated as follows:

Expected Value of Option

$(120 - 150) \times 0.1$	Not Exercised*
$(140 - 150) \times 0.2$	Not Exercised*
$(160 - 150) \times 0.5$	5
$(180 - 150) \times 0.1$	3
$(190 - 150) \times 0.15$	<u>6</u>
	<u>14</u>

* If the stock price goes below ₹ 150, option is not exercised at all.

19. (i) Total premium paid on purchasing a call and put option
 $= (\text{₹}30 \text{ per share} \times 100) + (\text{₹}5 \text{ per share} \times 100).$
 $= 3,000 + 500 = \text{₹}3,500$

In this case, X exercises neither the call option nor the put option as both will result in a loss for him.

Ending value = - ₹3,500 + zero gain = - ₹3,500

i.e Net loss = ₹3,500

- (ii) Since the price of the stock is below the exercise price of the call, the call will not be exercised. Only put is valuable and is exercised.

Total premium paid = ₹3,500

Ending value = - ₹3,500 + ₹[(450 - 350) × 100] = - ₹3,500 + ₹10,000 = ₹6,500

∴ Net gain = ₹6,500

- (iii) In this situation, the put is worthless, since the price of the stock exceeds the put's exercise price. Only call option is valuable and is exercised.

Total premium paid = ₹3,500

Ending value = -3,500 + [(600 - 550) × 100]

Net Gain = -3,500 + 5,000 = ₹1,500

20. **Net payoff for the holder of the call option**

(₹)					
Share price on exercise day	200	210	220	230	240
Option exercise	No	No	No	Yes	Yes
Outflow (Strike price)	Nil	Nil	Nil	220	220
Out flow (premium)	6	6	6	6	6
Total Outflow	6	6	6	226	226
Less inflow (Sales proceeds)	-	-	-	230	240
Net payoff	-6	-6	-6	4	14

Net payoff for the holder of the put option

(₹)					
Share price on exercise day	200	210	220	230	240
Option exercise	Yes	Yes	No	No	No
Inflow (strike price)	220	220	Nil	Nil	Nil

Less outflow (purchase price)	200	210	-	-	-
Less outflow (premium)	5	5	5	5	5
Net Payoff	15	5	-5	-5	-5

The call option can be exercised gainfully for any price above ₹226 (₹220 + ₹6) and put option for any price below ₹215 (₹220 - ₹5).

21.
$$p = \frac{e^{rt} - d}{u - d}$$

$$e^{rt} = e^{0.036}$$

$$d = 411/421 = 0.976$$

$$u = 592/421 = 1.406$$

$$p = \frac{e^{0.036} - 0.976}{1.406 - 0.976} = \frac{1.037 - 0.976}{0.43} = \frac{0.061}{0.43} = 0.1418$$

Thus probability of rise in price 0.1418

22. (i) To compute perfect hedge we shall compute Hedge Ratio (Δ) as follows:

$$\Delta = \frac{C_1 - C_2}{S_1 - S_2} = \frac{150 - 0}{780 - 480} = \frac{150}{300} = 0.50$$

Mr. Dayal should purchase 0.50 share for every 1 call option.

- (ii) Value of Option today

If price of share comes out to be ₹780 then value of purchased share will be:

Sale Proceeds of Investment (0.50 x ₹ 780)	₹ 390
Loss on account of Short Position (₹ 780 - ₹ 630)	₹ 150
	<hr/> ₹ 240 <hr/>

If price of share comes out to be ₹ 480 then value of purchased share will be:

Sale Proceeds of Investment (0.50 x ₹ 480)	₹ 240
--	-------

Accordingly, Premium say P shall be computed as follows:

$$(\text{₹ } 300 - P) 1.025 = \text{₹ } 240$$

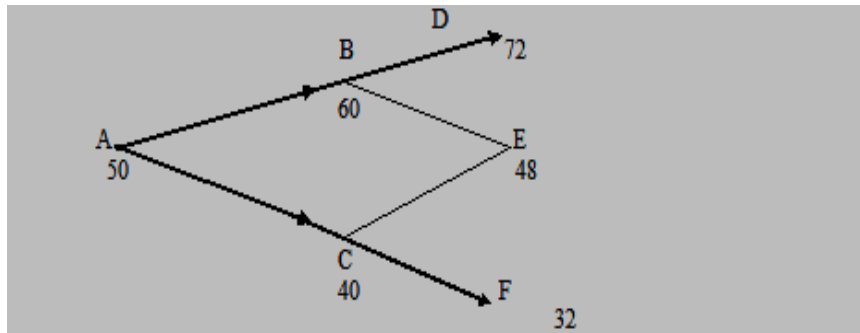
$$P = \text{₹ } 65.85$$

(iii) Expected Return on the Option

$$\text{Expected Option Value} = (\text{₹ } 780 - \text{₹ } 630) \times 0.60 + \text{₹ } 0 \times 0.40 = \text{₹ } 90$$

$$\text{Expected Rate of Return} = \frac{90 - 65.85}{65.85} \times 100 = 36.67\%$$

23. Stock prices in the two step Binominal tree

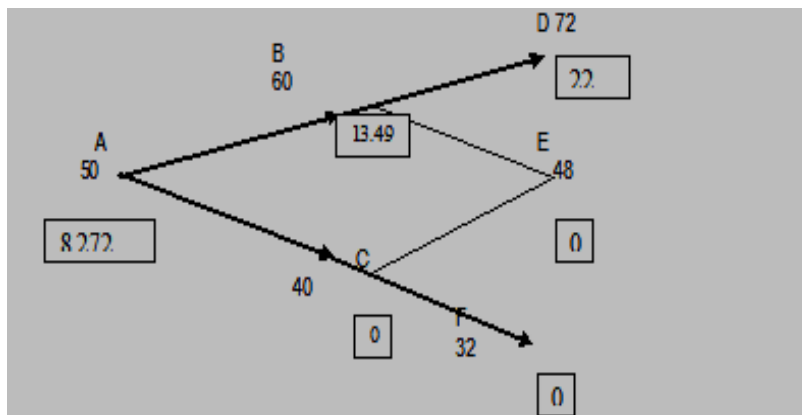


Using the single period model, the probability of price increase is

$$P = \frac{R - d}{u - d} = \frac{1.06 - 0.80}{1.20 - 0.80} = \frac{0.26}{0.40} = 0.65$$

therefore the p of price decrease = $1 - 0.65 = 0.35$

The two step Binominal tree showing price and pay off



The value of an American call option at nodes D, E and F will be equal to the value of European option at these nodes and accordingly the call values at nodes D, E and F will be 22, 0 and 0 using the single period binomial model the value of call option at node B is

$$C = \frac{C_u p + C_d (1 - p)}{R} = \frac{22 \times 0.65 + 0 \times 0.35}{1.06} = 13.49$$

The value of option at node 'A' is

$$\frac{13.49 \times 0.65 + 0 \times 0.35}{1.06} = 8.272$$

24. Let the probability of attaining the maximum price be p

$$(500 - 420) \times p + (400 - 420) \times (1-p) = 420 \times (e^{0.02} - 1)$$

$$\text{or, } 80p - 20(1 - p) = 420 \times 0.0202$$

$$\text{or, } 80p - 20 + 20p = 8.48$$

$$\text{or, } 100p = 28.48$$

$$p = 0.2848$$

$$\text{The value of Call Option in ₹} = \frac{0.2848 \times (500 - 450)}{1.0202} = \frac{0.2848 \times 50 + 0.7152 \times 0}{1.0202} = 13.96$$

25. Applying the Black Scholes Formula,

Value of the Call option now:

$$\text{The Formula } C = SN(d_1) - Ke^{(-rt)} N(d_2)$$

$$d_1 = \frac{\ln(S/K) + (r + \sigma^2 / 2)t}{\sigma\sqrt{t}}$$

$$d_2 = d_1 - \sigma\sqrt{t}$$

Where,

C = Theoretical call premium

S = Current stock price

t = time until option expiration

K = option striking price

r = risk-free interest rate

N = Cumulative standard normal distribution

e = exponential term

σ = Standard deviation of continuously compounded annual return.

ln = natural logarithm

$$d_1 = \frac{\ln(1.0667) + (12\% + 0.08)0.5}{0.40\sqrt{0.5}}$$

$$= \frac{0.0646 + (0.2)0.5}{0.40 \times 0.7071}$$

$$= \frac{0.1646}{0.2828}$$

$$= 0.5820$$

$$d_2 = 0.5820 - 0.2828 = 0.2992$$

$$N(d_1) = N(0.5820)$$

$$N(d_2) = N(0.2992)$$

$$\text{Price} = SN(d_1) - Ke^{(-rt)} N(d_2)$$

$$= 80 \times N(d_1) - (75/1.062) \times N(d_2)$$

Value of option

$$= 80 N(d_1) - \frac{75}{1.062} \times N(d_2)$$

$$N(d_1) = N(0.5820) = 0.7197$$

$$N(d_2) = N(0.2992) = 0.6176$$

$$\text{Price} = 80 \times 0.7197 - \frac{75}{1.062} \times 0.6176$$

$$= 57.57 - 70.62 \times 0.6176$$

$$= 57.57 - 43.61$$

$$= ₹13.96$$

Teaching Notes:

Students may please note following important point:

Values of $N(d_1)$ and $N(d_2)$ have been computed by interpolating the values of areas under respective numbers of SD from Mean (Z) given in the question.

It may also be possible that in question paper areas under Z may be mentioned otherwise e.g. Cumulative Area or Area under Two tails. In such situation the areas of the respective Zs given in the question will be as follows:

Cumulative Area

Number of S.D. from Mean, (z)	Cumulative Area
0.25	0.5987
0.30	0.6179
0.55	0.7088
0.60	0.7257

Two tail area

<i>Number of S.D. from Mean, (z)</i>	<i>Area of the left and right (two tail)</i>
0.25	0.8026
0.30	0.7642
0.55	0.5823
0.60	0.5485