Financial Derivatives – Instruments for Risk Management

13

This Module Includes:

13.1 Introduction to Financial Derivatives

13.2 Forward and Futures – Meaning and Difference, Pricing, Stock Futures, Index based Futures, Hedging through Futures

13.3 Options

13.4 Swaps

13.5 Interest Rate Derivatives – Forward Rate Agreement, Interest Rate Futures and Options, Caps, Floors and Collars

Financial Derivatives – Instruments for Risk Management

SLOB Mapped against the Module

To develop a detail understanding of the sources and impact of risks to which an organisation is exposed to in a dynamic business environment at national and international level and the techniques for managing the same to sustain competitive advantages. (CMLO 3b, 3c)

Module Learning Objectives:

After studying this module, the students will be able to -

- Understand the meaning of financial derivatives and their role in risk management.
- Develop an understanding of forward and future pricing and hedging using futures.
- Acquire in-depth knowledge of option pricing and developing option strategies for hedging and speculation.
- Understand the process of designing swap deals in interest rate swaps.
- Develop an idea about other interest rate derivatives and their uses in risk management.

Introduction to Financial Derivatives

13.1

13.1.1 Concept of Derivatives

In financial literature, the term 'derivative' refers to a contract which has no independent value but whose value is entirely derived from the value of the underlying asset. The underlying asset can be securities, commodities, bullion, currency, livestock or anything else. These are essentially financial products.

13.1.2 Functions of the Derivative Market

The derivatives market performs a number of economic functions. These are -

a. **Price Discovery:** Prices in an organized derivatives market reflect the perception of the market participants about the future and lead the prices of underlying to the perceived future level. The prices of derivatives converge with the prices of the underlying at the expiration of the derivative contract. Thus, derivatives help in discovery of future as well as current prices.

b. **Risk Transfer:** The derivatives market helps to transfer risks from those who have them but do not like them to those who have an appetite for them.

c. **Liquidity and Volume Trading:** Derivatives, due to their inherent nature, are linked to the underlying cash markets. With the introduction of derivatives, the underlying market witnesses higher trading volumes. This is because of participation by more players who would not otherwise participate for lack of an arrangement to transfer risk.

d. **More Participation:** An important incidental benefit that flows from derivatives trading is that it acts as a catalyst for new entrepreneurial activity. The derivatives have a history of attracting many bright, creative, well-educated people with an entrepreneurial attitude. They often energize others to create new businesses, new products and new employment opportunities, the benefit of which are immense.

13.1.3 Financial Derivatives

- **Concept of Financial Derivatives**

  Derivatives are broadly classified into two categories – Financial Derivatives and Commodity Derivatives.

  Financial derivatives, as the name suggest, are instruments whose value depends, or derives from, one or more underlying financial assets. The underlying assets include financial securities, security indexes, reference rates, and some combination of them.

- **Features of Financial Derivatives**

  A financial derivative shares the basic features of derivatives contract with an added specification that the underlying, in this case, is essentially a financial instrument or financial asset. These basic features of a derivative are as follows:

a. A derivative instrument relates to the future contract between two parties. It means there must be a contract-binding on the underlying parties and the same to be fulfilled in future.

b. The derivative instruments have the value which derived from the values of other underlying assets.

c. In general, the counter parties have specified obligation under the derivative contract.

d. The derivatives contracts can be undertaken directly between the two parties or through the particular exchange like financial futures contracts.

e. In general, the financial derivatives are carried off-balance sheet. The size of the derivative contract depends upon its notional amount. The payoff of derivative products differs from the payoff that their notional amount might suggest.

f. Usually, in derivatives trading, the taking or making of delivery of underlying assets is not involved; rather underlying transactions are mostly settled by taking offsetting positions in the derivatives themselves.

g. Derivatives are also known as deferred delivery or deferred payment instrument. It means that it is easier to take short or long position in derivatives in comparison to other assets or securities.

h. Derivatives are mostly secondary market instruments.

i. Though exchange traded derivatives are more popular, over-the-counter (OTC) traded derivatives are still in existence.

- **Benefits of Using Financial Derivatives**

The general benefits of using financial derivatives are as follows:

a. A prudent use of financial derivatives can provide a new mechanism to manage or reduce various business risks at low transaction costs.

b. The innovative use of financial derivatives can greatly help end-users on cut their financing cost.

c. Financial derivatives can provide more access to financial markets, especially to unfamiliar ones at lower costs. Put another way, they can create more complete markets to investors.

d. Financial derivative instruments play an important role in asset management due to their lower transaction costs relative to the spot market instruments.

e. The users of financial derivatives can expect to be offered opportunities on taking advantage of asymmetries in tax and regulatory requirements across different countries, markets or securities.

f. Financial derivatives can be used to speculate and make profits by assuming certain risks, probably with suitable degree.

⊙ **Types of Financial Derivatives**

Financial derivatives can be categorized based on the nature of the contract as well as based on the underlying assets.

A. Based on the Nature of the Contract

According to the nature of the contract, financial derivatives can be classified into basic and complex derivatives.

I. Basic Derivatives

The most commonly used derivatives contracts are –

(a) Forwards: A forward contract is a customized contract between two entities, where settlement takes place on a specific date in the future at today's pre-agreed price. Forwards are very popular in foreign exchange market.

(b) Futures: A futures contract is an agreement between two parties to buy or sell an asset at a certain time in the future at a certain price. Futures contracts are special types of forward contracts in the sense that the former are standardized exchange-traded contracts. Unlike forward contracts, the counterparty to a futures contract is the clearing corporation on the appropriate exchange.

(c) Options: An option represents the right (but not the obligation) to buy or sell a security or other asset during a given time for a specified price (the "strike price"). Options are of two types - calls and puts.

(d) Swaps: Swaps are private agreements between two parties to exchange cash flows in the future according to a prearranged formula. They can be regarded as portfolios of forward contracts. Swaps generally are traded OTC through swap dealers, which generally consist of large financial institution, or other large brokerage houses.

II. Complex Derivatives:

These are derivatives which are built up from two or more other derivatives. Some examples include –

(a) Warrants: Options generally have lives of up to one year, the majority of options traded on options exchanges having a maximum maturity of nine months. Longer-dated options are called warrants and are generally traded over-the-counter.

(b) LEAPS: The acronym LEAPS means Long-term Equity Anticipation Securities. These are options having a maturity of up to three years.

(c) Baskets: Basket options are options on portfolios of underlying assets. The underlying asset is usually a moving average of a basket of assets. Equity index options are a form of basket options.

(d) Swaptions: Swaptions are options to buy or sell a swap that will become operative at the expiry of the options.

B. Based on the Underlying Assets

Based on the underlying assets, financial derivatives can be of the following types:

(a) Equity Derivatives: Equity derivatives are financial instruments whose value is derived from price movements of the underlying asset, where that asset is a stock or stock index. These are generally stock and index futures and option contracts.

(b) Interest Rate Derivatives: Interest Rate Derivative ae financial derivative contracts whose value is derived from one or more interest rates, prices of interest rate instruments, or interest rate indices. In India, popular interest rate derivatives include Interest Rate Futures or Interest Rate Options.

(c) Foreign Exchange Derivatives: A foreign currency derivative is a financial derivative whose payoff depends on the foreign exchange rates of two (or more) currencies. These instruments are commonly used for hedging foreign exchange risk or for currency speculation and arbitrage. Specific foreign exchange derivatives include: foreign currency forward contracts, foreign currency futures, foreign currency swaps, currency options, and foreign exchange binary options.

(d) Credit Derivatives: A credit derivative is a contract whose value depends on the creditworthiness or a credit event experienced by the entity referenced in the contract. Credit derivatives include credit default swaps, collateralized debt obligations, total return swaps, credit default swap options, and credit spread forwards.

Forward and Futures – Meaning and Difference, Pricing, Stock Futures, Index based Futures, Hedging through Futures

13.2

13.2.1 Forward Contracts

⊙ **Concept of Forward Contract**

A forward contract is a simple tailor-made contract between two parties to buy or sell an asset at a certain time in the future for a pre-determined price. Unlike future contracts, they are not traded on an exchange, rather traded in the over-the-counter market, usually between two financial institutions or between a financial institution and one of its clients.

Consider the following example of a forward contract in foreign exchange market.

An Indian company buys computer parts from USA with payment of ten million dollar due in 90 days. The importer, thus, owes dollars for future delivery. Suppose present price of dollar is ₹68. Over the next 90 days, however, dollar might rise against ₹68. The importer can hedge this exchange risk by negotiating a 90-days forward contract with a bank at a price ₹70. According to forward contract in 90 days the bank will give importer ten million dollar and importer will give the bank 700 million rupees hedging a future payment with forward contract. On the due date importer will make a payment of ₹700 million to bank and the bank will pay ten million dollar to importer, whatever rate of the dollar is after 90 days. So, this is a typical example of forward contract on currency.

⊙ **Features of Forward Contract**

The basic features of a forward contract are given in brief here as under:

a. Forward contracts are bilateral contracts, and hence, they are exposed to counter-party risk. There is risk of non-performance of obligation either of the parties.

b. Each contract is custom designed, and hence, is unique in terms of the asset type, quality, contract size and expiration date etc.

c. In forward contract, one of the parties takes a long position by agreeing to buy the asset at a certain specified future date. The other party assumes a short position by agreeing to sell the same asset at the same date for the same specified price.

d. The pre-determined specified price in a forward contract is referred to as the delivery price. The forward price for a particular forward contract at a particular time is the delivery price that would apply if the contract were entered into at that time. Thus, both are equal at the time the contract is entered into but, as time passes, the forward price is likely to change whereas the delivery price remains the same.

e. In the forward contract, derivative assets can often be contracted from the combination of underlying assets, such assets are often known as synthetic assets in the forward market.

f. In the forward market, the contract has to be settled by delivery of the asset on expiration date.

g. In the forward contract, covered parity or cost-of-carry relations are relation between the prices of forward and underlying assets. Such relations further assist in determining the arbitrage-based forward asset prices.

h. Forward contracts are very popular in foreign exchange market as well as interest rate bearing instruments.

⊙ **Types of Forward Contract**

Based on the underlying asset, forward contracts can be classified into –

a. Commodity Forwards – Here the underlying is any commodity like Gold.

b. Currency Forwards – Here the underlying is the foreign exchange.

c. Equity Forwards – Here the underlying is an individual stock, a stock portfolio or a stock index.

d. Interest Rate Forwards - Here the underlying is the interest rate itself.

According to Forward Contracts (Regulation) Act, 1952, forward contracts are of the following three major categories.

a. Hedge Contracts

b. Transferable Specific Delivery Forward Contracts

c. Non-transferable Specific Delivery Forward Contrcat

⊙ **Forward Market Mechanism**

A forward contract is an effective tool for hedging and is similar to an insurance policy, as it protects a trader from unfavourable movements in the asset prices. The trading mechanism of forward contracts can be better understood with the help of the following example.

Suppose, Mr. X has imported certain automobile parts from USA for which it requires to pay the exporter one million US $ in 3 months. The current rupee-dollar exchange rate is ₹75/US$. Mr. X apprehends that the rate may go up to ₹78/US$. In order to protect himself from the adverse movement in exchange rate, Mr. X will enter into a forward buying contract to buy one million US $ after 3 months at a forward price, say ₹76/US $. If after 3 months, on the date of maturity of the contract, the rate moves beyond ₹76/US $, Mr. X will still be able to buy US $ at ₹76/US $ and thereby will hedge his loss.

⊙ **Forward Terminology**

a. Underlying Asset: This refers to the asset on which forward contract is made.

b. Long Position: The party that agrees to buy an underlying asset (e.g., stock, commodity, stock index, etc.) in a future date is said to have a long position.

c. Short Position: The party that agrees to sell an underlying asset (e.g., stock, commodity, indices, etc.) in future date is said to have a short position.

d. Spot Position: It refers to the quoted price of the underlying asset for buying and selling at immediate delivery.

e. Future Spot Price: This is the spot price of the underlying asset on the date of expiration of the forward contract.

f. Delivery Price: It is the pre-specified price of the underlying assets at which the forward contract is settled.

⊙ **Profit Profile of Buyer and Seller**

The buyer of the underlying commodity or asset is referred to as the long side whereas the seller is the short

side. The obligation to buy the asset at the agreed price on the specified future date is referred to as the long position. A long position profits when prices rise. The obligation to sell the asset at the agreed price on the specified future date is referred to as the short position. A short position profits when prices go down.

Let T denote the expiration date, K denote the forward price, and PT denote the spot price (or market price) at the delivery date. Then –

a. For the long position: the payoff of a forward contract on the delivery date is PT - K

b. For the short position: the payoff of a forward contract on the delivery date is K - PT

Accordingly, the pay-off profile of Long Forward and Short Forward will be as follows.

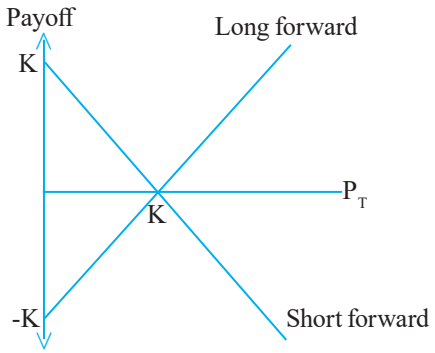


Figure 13.1: Pay-off Profile Forward Buyer and Seller

From the above diagram, it may be seen that both the long and short forward payoff positions break even when the spot price is equal to the forward price. Moreover, long forward's maximum loss is the forward price whereas the maximum gain is unlimited. For a short forward, the maximum gain is the forward price and the maximum loss is unlimited. Pay-off diagrams show the pay-off of a position at expiration only.

Consider the following illustration.

Illustration 1

An investor sells 10 million yen forward at a forward price of $0.0090 per yen. At expiration, the spot price is $0.0083 per yen.

(a) What is the long position payoff?

(b) What is the short position payoff?

Solution:

(a) At the expiration date, the long position's payoff is (0.0083 – 0.009) × 10 = (–) $ 0.007 million i.e., a loss of $ 0.007 million.

(b) The short position's payoff is a profit of $ 0.007 million.

⊙ Advantages and Disadvantages of Forward Contract

The advantages of Forward Contracts include the following:

(a) These are used to hedge the price for purchase or sale of commodity or financial asset on the future commitment date.

(b) Forward contracts do not require any upfront premium. So, they do not involve initial cost.

(c) These contracts are tailor-made. Therefore, price risk exposure can be hedged up to 100%, which may not be possible in futures or options as these are standardized.

However, Forward Contracts suffer from some limitations also. The major disadvantages of Forward Contracts are:

(a) There is lack of centralized trading system like Futures. These are 'Over the Counter (OTC)' derivatives.

(b) As these do not have an organized secondary market, these are illiquid.

(c) Due to absence of any recognized exchange as the intermediary, these contracts involve substantial amount of counterparty risk.

13.2.2 Future Contracts

⊙ **Concept of Future Contract**

A future contract is a standardized agreement between the buyer and seller of the contract traded on a futures exchange, to buy or sell a specified underlying asset at a certain date in future, at a pre-set price. The future date is called the delivery date or final settlement date. The pre-set price is called the futures price. The price of the underlying asset on the delivery date is called the settlement price.

Thus, a future contract is a standard contract in which the seller is obligated to deliver a specified asset (security, index, commodity or foreign exchange) to the buyer on a specified date in future and the buyer is obligated to pay the seller the then prevailing futures price upon delivery.

⊙ **Characteristics of a Future Contract**

Following are the characteristics of a future contract.

(a) Exchange Traded: Future contracts are exchange traded. This provides a ready liquid market in which futures can be bought and sold. Some of these exchanges are Chicago Mercantile Exchange, Philadelphia Board of Trade, London International Financial Futures Exchange (LIFFE), Tokyo International Financial Futures Exchange (TIFFE), Sydney Futures Exchange, and Singapore International Monetary Exchange (SIMEX). In India, currency futures are sold at BSE and NSE.

(b) Selective Assets: The underlying of Financial Futures may be a security, index or foreign exchange. However, these are not available on all assets under a given category. For example, Stock Futures in NSE are available on 196 selected securities. Similarly, Index Futures are available on Nifty 50, Nifty Bank, Nifty Midcap Select, Nifty Financial Services. Currency futures, also, are not available on all foreign currencies.

(c) Standardisation: The contract is standardised as to quantity, date and month of delivery and the minimum amount by which price would move. A brief explanation follows:

- **Quantity:** Each deal has a market lot. Thus, if you want to enter into a futures contract in Reliance stock, you will have to buy 100Reliance, or in multiples thereof. Also referred to as the size of the contract, it specifies the quantity of the asset to be delivered for on contract.
- **Quality:** If you have entered into a futures contrast to sell 100 Infosys stock futures you will have to deliver 100 Infosys shares and not 100WIPRO shares.
- **Date and month of delivery:** The date and month of delivery is determined by the exchange. As of now the exchange has fixed the last Thursday of the month for settlement and delivery. You cannot enter into a futures contract to deliver on say a Friday or a Wednesday. Further, if you have contracted to deliver in October, you have to deliver in October and cannot have it postponed to November.

- **Units of price quote:** The minimum, and sometimes the maximum amount by which the price would change, is specified.

Thus "Reliance October stock futures" becomes a standard asset like any other asset that can be traded in the market.

d) **Clearing House:** In case of futures contracts, buyers and sellers do not come face-to-face. They operate through the clearing house. Clearing house is an entity that acts as counterparty to each transaction on futures market. Clearing house has the responsibility of maintaining accounts, margin payments and settlement of deliveries. A clearing house serves as the third party to all transactions. That is, the buyer of a futures contract effectively buys from the clearing house and the seller of a futures contract sells to the clearing house. This reduces the counterparty risk.

e) **Settlement Price:** Since the futures contracts are performed through a particular exchange, so at the close of the day of trading, each contract is marked-to-market (will be discussed in detail later in this section). For this the exchange establishes a settlement price. This settlement price is used to compute the profit or loss on each contract for that day. Accordingly, the member's accounts are credited or debited.

f) **Daily Settlement and Margin:** Another feature of a futures contract is that when a person enters into a contract, he is required to deposit funds with the broker, which is called as margin. The exchange usually sets the minimum margin required for different assets, but the broker can set higher margin limits for his clients which depend upon the credit-worthiness of the clients. The basic objective of the margin account is to act as collateral security in order to minimize the risk of failure by either party in the futures contract.

g) **Cash Settlement:** Most of the futures contracts are settled in cash by having the short or long to make cash payment on the difference between the futures price at which the contract was entered and the cash price at expiration date. This is done because it is inconvenient or impossible to deliver sometimes, the underlying asset such as in case of Index Futures.

h) **Delivery:** The futures contracts are executed on the expiry date. The counter parties with a short position are obligated to make delivery to the exchange, whereas the exchange is obligated to make delivery to the longs. The period during which the delivery will be made is set by the exchange which varies from contract to contract.

i) **Regulation:** Since Futures are exchange traded, they are well regulated by the market regulators. In India, RBI is empowered to regulate the interest rate derivatives, foreign currency derivatives and credit derivatives. Regulation of other types of derivatives comes under the purview of SEBI.

⊙ Types of Future Contracts

On the basis of the underlying asset, Futures contracts can be classified into the following types:

a. **Stock Futures:** These are Futures Contract on individual securities or stock. A stock futures contract is a commitment to buy or sell the financial exposure equivalent to a specific number of shares of the underlying stock at a predetermined price on a specified future date.

b. **Index Futures:** A stock index futures contract is a contract to buy or sell the face value of the underlying stock index where the face value is defined as being the value of index multiplied by the specified monetary amount. This device makes it possible to equate the value of the stock index with that of a specific basket of shares.

c. **Currency Futures:** A Currency Futures Contract is a commitment to either to buy or to sell a specified amount of a foreign currency on a future date at a specified exchange rate. They are extremely standardized in terms of available currencies, delivery dates, contract size.

d. **Interest Rate Futures:** An Interest Rate Futures contract is "an agreement to buy or sell a debt instrument at a specified future date at a price that is fixed today." At NSE the underlying security for Interest Rate Futures is either Government Bond or T-Bill. Exchange traded Interest Rate Futures on NSE are standardized contracts based on 6 year, 10 year and 13 year Government of India Security (NBF II) and 91-day Government of India Treasury Bill (91DTB). All futures contracts available for trading on NSE are cash settled.

⊙ **Future Contract Terminology**

a. **Spot price:** The price at which an underlying asset is traded in the spot market.

b. **Futures price:** The price that is agreed upon at the time of the contract for the delivery of an asset at a specific future date.

c. **Contract cycle:** It is the period over which a contract is traded.

d. **Expiry date:** It is the date on which the final settlement of the contract takes place.

e. **Contract size:** The amount of asset that has to be delivered for one contract. This is also called as the lot size.

f. **Basis:** Basis is defined as the futures price minus the spot price. There will be a different basis for each delivery month for each contract. In a normal market, basis will be positive. This reflects that futures prices normally exceed spot prices.

⊙ **Forward Contracts vs. Future Contracts**

Following are the major differences between Forward Contracts and Future Contracts:

	Criteria	Forwards	Futures
1.	Standardization	Not standardization but negotiated	Standardized.
2.	Trading	Over the Counter	Exchange Traded
3.	Mode of Delivery	Cash settled or delivery	Normally cash settled.
4.	Transaction cost	Bid-ask spread	Includes brokerage fee
5.	Liquidity	Not liquid	Highly liquid
6.	Frequency of Physical Delivery	90% of all forward contracts are settled by actual delivery.	Very few future contracts are settled by actual delivery
7.	Margin	Not required	Required
8.	No. of contracts	Any number	Fixed annually
9.	Settlement	On expiry	Daily settlement

⊙ **Marking to Market**

Marking to market essentially means that at the end of the trading session (day), all outstanding contracts are repriced at the settlement price of that session (daily closing price). Margin account of those who made losses at debited and of those who gained are credited. The daily settlement reduces the default risk of futures contract relative to forward contracts.

Suppose, an investor takes a long position (i.e., agreed to buy) in an ACC futures contract with lot size 250 that matures on Thursday afternoon. The agreed upon price is. ₹2,100 per share. At the close of trading on Tuesday, the futures price has increased to ₹2,150. Due to the daily settlement feature, three things will occur.

First, the investor will receive his cash profit of ₹12,500. Second, the existing futures contract with price of ₹2,100 will be cancelled and third the investor will receive a new futures contract with the prevailing price of ₹2,150.

⊙ Margin Requirement

Before entering into a futures contract, the prospective trader (investor) must deposit some funds with his broker which serve as a good faith deposit. In other words, an investor who enters into a futures contract is required to deposit funds with the broker called a margin. The basic objective of margin is to provide a financial safeguard for ensuring that the investors will perform their contract obligations.

In a futures market, there are three types of margin requirements – Initial (Minimum) Margin and Maintenance Margin.

(a) Initial Margin: The initial margin is the original amount that must be deposited into account to establish futures position. It varies from stock to stock. To determine the initial margin, the exchange usually considers the degree of volatility of price movements in the past of the underlying the asset. After that, the exchange sets the initial margin so that the clearing house covers losses on the position even in most adverse situation. The initial margin approximately equals the maximum daily price fluctuation permitted by the exchange for that underlying asset.

(b) Maintenance Margin: The maintenance margin is the minimum amount which must be remained (kept) in a margin account. If the balance of margin account falls below the maintenance margin level, the broker will make a margin call and ask the investor to deposit the amount so that the balance again reach the initial margin level.

If a margin call is made additional money is deposited by the trader/investor, to bring the account to the level of initial margin. This amount is called as the variation margin. In short variation margin is the amount needed to restore the initial margin once a margin call has been issued. The variation margin may change depending on how far the margin account has fallen below the maintenance margin level.

For example, assume that the initial margin on a futures contract is ₹ 5,000 and the maintenance margin ₹3,750 (75% of the initial margin). The next day assume that the party has sustained a loss of ₹1,000, reducing the balance in margin to ₹4,000. Further assume that on the next day the price decreased and sustained loss is ₹500. Thus, the balance remained in the margin account to ₹3,500, below the maintenance margin. In this situation, the broker will make a call (margin call) to replenish the margin account to ₹5,000, the level of initial margin.

Consider the following illustration.

Illustration 2

On June 15, Mr. X establishes a long position in 200 shares of Tata Steel on July 1 at a futures price ₹ 600 per share. Initial margin for contract is ₹30,000 and maintenance margin is ₹20,000. Future prices on June 16, 17, 18, 19, 21, 22, 23, 24 are ₹550, ₹650, ₹600, ₹605, ₹590, ₹580, ₹600, ₹620. Calculate his daily profit and loss, margin contribution/withdrawal and balance in the margin account.

Solution:

Calculation of daily profit/loss, margin contribution/ withdrawal and margin account balance (Contract Size 200 shares)

Day	Future Price (₹)	Daily gain/losses	Margin Contributions (+) Withdrawal (–)	Balance in Margin Account
June 15	600	–	–	30,000
June 16	550	(–) 10,000	–	20,000
June 17	650	+ 20,000	(–) 10,000	30,000
June 18	600	(–) 10,000	+ 10,000	30,000
June 19	605	+ 1,000	(–) 1,000	30,000
June 21	590	(–) 3,000	+ 3,000	30,000
June 22	580	(–) 2,000	+ 2,000	30,000
June 23	600	+ 4,000	(–) 4,000	30,000
June 24	620	+4,000	(–) 4,000	30,000

Concept of Continuous Compounding

The concept of continuous compounding is closely associated with the calculation of theoretical forward and future prices. The concept is an extension of general periodical compounding.

We know that, if a sum P carrying r rate of interest p.a. for n years is compounded annually, then the compounded value will be, $A = P(1+r)^n$.

For example, a sum of ₹10,000 compounded at 10% p.a. for 2 years becomes

$$A = P(1+r)^n = 10,000\ (1+0.10)^2 = ₹12,100$$

Now, if the compounding is done for semi-annually, quarterly or monthly, then the compounded value of P with say, 'm' no. of compounding per year, will be

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

Where m = 2 for semi-annually, 4 for quarterly and 12 for monthly compounding. Similarly, for daily compounding m = 365.

If the compounding frequency is increased further, it can be shown mathematically that the compounded value of P with r rate of interest continuously compounded for n years will be

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

Similarly, for continuous discounting, the PV factor $\frac{1}{(1+r)^n} = (1+r)^{-n}$ can be replaced by e^{-nr}.

Thus, in our example, after 2 years, ₹10,000 with interest rate 10% p.a. continuously compounded will become

$$A = P \times e^{nr} = 10,000 \times e^{0.10 \times 2} = ₹12,214$$

Pricing of Financial Forward and Futures

The financial forward and futures contracts are priced using the Cost of Carry Model. With varying degrees of success, the model can also be used to value some non-financial contracts such as Gold.

The pricing is done in such a way that no arbitrage opportunities arise. Arbitrage refers to a trade which leads to a risk-free profit with no cash outlay. It is not expected to be present in the markets operating well, but market imperfections, such as transactions costs, etc., do allow arbitrage opportunities and, therefore, the actual prices may deviate from their theoretical values that are calculated by the model.

- **Assumptions of the Model**

  The Cost of Carry Model is based on certain fundamental assumptions.

  a. The markets are perfect.
  b. There are no transaction costs.
  c. All the assets are infinitely divisible.
  d. Bid-ask spreads do not exist so that it is assumed that only one price prevails.
  e. There are no restrictions on short selling. Also, short sellers get to use full proceeds of the sales.
  f. Traders are ready to take advantage of arbitrage opportunities as and when arise.

- **Notations Used**

  Following are the notations to be used in the model:

  T = Time remained up to delivery date in the contract

  S = Price of the underlying asset at present, also called as spot or cash or current

  K = Delivery price in the contract at time T

  F* = Theoretical Forward or future price today = TFP

  F = Actual Forward or Future price today = AFP

  r = Risk free rate of interest per annum today

- **The Model**

  The carry pricing model stipulates that the forward or futures price, defined as the value of one unit of the asset underlying the contract, is equal to the sum of the spot price and the carrying costs incurred by buying and holding on to the deliverable asset, less the carry return, if any. Thus, Forward (or Futures) Price = Spot Price + Carry Costs – Carry Return

  Here, Spot Price is the current price of one unit of the deliverable asset in the market. Carry Costs refer to the holding costs, including the interest charges on borrowing the cash to buy (or the opportunity cost of using one's own funds) the asset. In case of physical commodities, the carrying costs also include costs such as insurance, obsolescence, storage, etc. Carry Return refers to the income, such as dividends on shares, which may accrue to the investor.

- **Pricing of Forward Contracts (on Investment Assets i.e., Securities)**

  A. For Securities Providing No Income

  This is the easiest forward contract to value, and is exemplified by a share which is not expected to pay any dividend, or by discount bonds. In order that there be no arbitrage opportunities, the forward price should be:

  $$TFP = F^* = S_0 e^{rt}$$

  Here, S_0 is the spot price of the asset underlying the contract, r is the risk-free rate of interest per annum with continuous compounding, and t is the time to maturity.

  Now, if TFP(F) > AFP(F*), then the arbitrageur can buy the asset and will go for short forward contract on the asset.

  But, if TFP(F) < AFP(F*), then he can short the asset and go for long forward contract on it.

  Consider the following illustration.

Illustration 3

Mr. X is long on a forward contract to purchase a non-dividend paying share in 3 months. The current market price of the share is ₹70 and the three-month risk-free rate of interest is 6% p.a. continuously compounded. Calculate the theoretical forward price. Is there any arbitrage opportunity if the actual forward price is (i) ₹73 and (ii) ₹71?

Solution:

Given, S_0 = ₹70; r = 6% p.a.c.c; t = 3 months = 3/12 years.

So, theoretical forward price,

$F^* = S_0 e^{rt} = 70 \times e^{0.06 \times 3/12} = 70 \times 1.0202 =$ ₹71.41

(i) When the three months forward price is ₹73, the arbitrageur can borrow ₹70 @ 6% for three months, buy one share at ₹70 and short a forward contract for ₹71.41. At the end of three months, the arbitrageur sells the share for ₹73, repay the loan amount of ₹71.41 and make a profit of ₹(73 – 71.41) = ₹1.59

(ii) If the three-month forward price is ₹71, the arbitrageur can short one share, invest the proceeds of the short sale at 6 percent per annum for three months, and have a long position in a three-month forward contract. The proceeds of short sales will grow to ₹71.41 at the end of three months. The arbitrageur will pay ₹71 and take the delivery of the share under forward contract, and uses it to close its short sale position. His net gain is ₹ (71.41 – 71) = ₹0.41.

B. For Securities Providing a Known Cash Income

Let the present value of the known cash income = I, then, the forward price should be:

$$F^* = (S_0 - I).\ e^{rt}$$

Now, if that F > F*, an arbitrageur can short a forward contract, borrow money and buy the asset. When the income is received, the same is used to partly repay the loan. At maturity, the asset is sold for F and the outstanding loan of is repaid. This result in a net profit of $(S_0 - I)e^{rt}$. On the other hand, if F< F*, then an arbitrageur can short the asset, invest the proceeds, and take a long position in a forward contract. This operation will yield net gain of $[(S_0 - I)\ e^{rt} - F]$ at maturity.

Consider the following illustration.

Illustration 4

A 6-month forward contract on 100 shares with a price of ₹38 each is available. The risk-free rate of interest (continuously compounded) is 10% per annum. The share in question is expected to yield a dividend of ₹1.50 in 4 months from now. Determine the forward price.

Solution:

Given, S_0 = ₹38; r = 10% p.a.c.c; t = 6 months = 6/12 years.

I = PV of dividend = $1.50 \times e^{-0.10 \times 4/12} = 1.4508$

So, theoretical forward price,

$F^* = (S_0 - I)e^{rt} = (38 - 1.4508) \times e^{0.10 \times 6/12} =$ ₹38.4231

So, the forward price should be ₹38.4231.

C. For Securities Providing a Known Yield

Instead of a known cash income, securities may provide a certain yield. Stock indices may be regarded as such securities. The shares included in the portfolio comprising the index are expected to return dividends in the course of time which may be expressed as a percentage of their prices, termed as yield, and thus be related to

the index. Theoretically, it is assumed to be paid continuously at a rate of y per annum.

In such a case, the forward price will be calculated as follows:

$$F^* = S_0 e^{(r-y)t}$$

Consider the following illustration.

Illustration 5

Consider a 6-month forward contract on a security where 4% p.a. continuous dividend is expected. The risk-free rate of interest is 10% p.a. continuously compounded. The asset's current price is ₹25. Determine the forward price.

Solution:

Given, S_0 = ₹25; r = 10% p.a.c.c; t = 6 months = 6/12 years; y = 4% p.a

So, theoretical forward price,

$F^* = S_0 e^{(r-y)t}$

$= 25 \times e^{(0.10-0.04)\times 6/12} =$ ₹25.76

Note: Value of a Forward Contract

On the basis of generalization in different situations, the value of a forward contract can be determined. The value of a forward contract at the time it is first written (entered) into is zero. However, at later stage, it may prove to have a positive or negative value. In general, the value of a long forward contract can be determined as follows:

$$f = (F^* - K)e^{-rt}$$

where, f = value of the forward contract, F* = Forward price, K = delivery price

Similarly, the value of a short forward contract can be determined as follows:

$$f = (K - F^*)e^{-rt}$$

Consider the following illustration.

Illustration 6

Consider a 6 month long forward contract on a non-dividend paying stock. The risk-free rate of interest is 6% p.a. continuously compounded. The current stock price is ₹60 and the delivery price is ₹56. Compute the value of the forward contract.

Solution:

Given, S_0 = ₹60; r = 6% p.a.c.c; t = 6 months = 6/12 years; K = ₹56

So, $F^* = S_0 e^{rt} = 60 \times e^{0.06 \times 6/12} =$ ₹61.80

Value of the long forward contract = $f = (F^* - K)e^{-rt} = (61.80 - 56)e^{-0.06 \times 6/12} =$ ₹5.62

Pricing of Futures Contracts (Stock and Index Futures)

Comparable forward and futures prices tend to be practically the same. In fact, it may be shown that in a perfect market where the interest rates remain unchanged, the futures prices would equal the forward prices, with the marking to the market having no impact on the prices. However, when interest rates are variable, the two may be different. Broadly speaking, if movements in the futures prices are positively correlated to the interest rates, then the futures prices are likely to be higher than the forward prices. As futures' prices increase, long

positions on futures are profitable. If the interest rates also rise simultaneously (a positive correlation), then the marking to market cash inflows can be reinvested at higher rates. Similarly, if interest rates fall when futures prices fall (still a positive correlation) then losses that long position holders incur can be offset by borrowing at lower interest rates. Consequently, the futures prices tend to be bid higher in relation to the forward prices. The reverse happens when the futures prices and interest rates are negatively correlated. That is to say, when interest rates tend to decline with an increase in the futures prices, then the cash flows resulting from marking to the market would be reinvested at lower interest rates, while increased interest rates associated with falling futures prices would imply that losses to long position on futures have to be offset by borrowing at higher rates of interest. This has the effect of bidding lower futures prices than those of forward contracts.

However, these results tend to hold in case of perfect markets. In the imperfect real world, markets, this does not work so well - the presence of transactions costs, indivisibilities and taxes tend to weaken these propositions. Accordingly, the futures prices may be reasonably taken to be the same as forward prices derived from the cost of carry model.

A. Pricing of Stock Futures

The formula for determining the future price of a stock future is exactly similar to that of the forward price. So, it will not be discussed separately.

B. Pricing of Index Futures

With reference to the previous discussion on forward pricing, the theoretical futures price under three situations can be determined as follows:

a. When the securities included in the index are not expected to pay any dividends during the life of the contract

$$F^* = S_0 e^{rt}$$

b. When dividend is expected to be paid by one or more of the securities included in the index during the life of the contract.

$$F^* = (S_0 - I). e^{rt}$$

c. When dividend on the securities included in the index is assumed to be paid continuously during the life of the contract. (i.e., dividend yield is known)

$$F^* = S_0 e^{(r-y)t}$$

Where, F* is the future price.

Consider the following illustration.

Illustration 7

Tripti has two investment opportunities, M and N, carrying an yield of 15% p.a. the tenor of both these investments is 3 years.

M offers continuous compounding facility, whereas N offers yield on the basis of monthly compounding. Which offer will Tripti opt for?

If continuous compounding facility comes at a price of ₹180 p.a. per lakh of deposit (chargeable at the end of the period), what will be the position?

At what price, will Tripti be indifferent to Continuous Compounding Facility and Monthly Compounding?

Solutions:

1. Return on Investment

Particulars	Investment M	Investment N
Investment (assumed)	₹20,00,000	₹20,00,000
Amount receivable on Maturity (A)	$A = P \times e^{r \times t}$ $= ₹20,00,000 \times e^{0.15 \times 3}$ $= ₹20,00,000 \times e^{0.45}$ $= ₹20,00,000 \times 1.5683$ $= ₹31,36,600$	$A = P \times (1 + r/m)^{n \times m}$ $= ₹20,00,000 \times (1 + 0.15/12)^{3 \times 12}$ $= ₹20,00,000 \times (1 + 0.0125)^{36}$ $= ₹20,00,000 \times (1.0125)^{36}$ $= ₹20, 00,000 \times 1.563944$ $= ₹31,27,888$
Charges payable at ₹180 p.a. per lakh	20 × ₹180 p.a. × 3 years = ₹10,800	Nil
Net Amount Receivable upon Maturity	₹31,36,600 – ₹10,800 = ₹31,25,800	₹31,27,888 – Nil = ₹31,27,888

2. Evaluation of Investments

Case A (No charges for continuous compounding): Investment M is preferable, as it offers a higher return on maturity.

Case B (Charges for Continuous Compounding): Investment N is preferable, as amount receivable is higher than net amount receivable in Investment M.

3. Indifference Point

Tripti will be indifferent to Investment M and N, if

Amount Receivable under Maturity in Investment N	=	Amount Receivable under Maturity in Investment M	Less	Charges for Continuous Compounding

⇨ ₹31,27, 888 = ₹31,36,600 Less Charges

⇨ Charges = ₹31,36,600 Less ₹31,27,888 = ₹8,712

⇨ Chagres per Lakh per Annum = ₹8,712 ÷ (3 Years × 20)
= ₹8,712 ÷ 60
= ₹145.20

Conclusion: the price payable for Investment M is ₹145.20 per lakh per annum for Tripti to be indifferent to both the investment alternatives.

Illustration 8

Theoretical Forward Price - No Dividends, No Carrying Cost Compute the theoretical forward price of the following securities for 1 month, 3 months and 6 months –

Securities of	DD Ltd.	EE Ltd.	FF Ltd.
Spot price [S_o]	₹160	₹2,600	₹600

You may assume a risk free interest rate of 9% p.a. and 12% p.a.

Solution:

1. Theoretical Forward Price

Theoretical Forward Price of Security × $[F_x] = S_x \times e^{rt}$

Where, S_x = Current Spot Price of Security X

r = Rate of Interest

t = Period in Years

2. Forward Price of Securities of the Companies

a) DD Ltd.

Period (t)	r = 9% p.a. or 0.09	r = 12% p.a. or 0.12
1 Month or 1/12 year i.e. 0.0833	$F_A = ₹160 \times e^{0.09\times0.0833}$ $= ₹160 \times e^{0.0075}$ $= ₹160 \times 1.007528$ $= ₹161.20$	$F_A = ₹160 \times e^{0.12\times0.0833}$ $= ₹160 \times e^{0.01}$ $= ₹160 \times 1.01005$ $= ₹161.608$
3 Months or 3/12Year i.e. 0.25	$F_A = ₹160 \times e^{0.09\times0.25}$ $= ₹160 \times e^{0.0225}$ $= ₹160 \times 1.022755$ $= ₹163.641$	$F_A = ₹160 \times e^{0.12\times0.25}$ $= ₹160 \times e^{0.03}$ $= ₹160 \times 1.030456$ $= ₹164.873$
6 Months or 6/12 i.e. 0.50	$F_A = ₹160 \times e^{0.09\times0.50}$ $= ₹160 \times e^{0.045}$ $= ₹160 \times 1.046028$ $= ₹167.3645$	$F_A = ₹160 \times e^{0.12\times0.50}$ $= ₹160 \times e^{0.06}$ $= ₹160 \times 1.061837$ $= ₹169.8939$

(b) EE Ltd.

Period (t)	r = 9% p.a. or 0.09	r = 12% p.a. or 0.12
1 Month or 1/12 year i.e. 0.0833	$F_A = ₹2,600 \times e^{0.09\times0.0833}$ $= ₹2,600 \times e^{0.0075}$ $= ₹2,600 \times 1.007528$ $= ₹2,619.573$	$F_A = ₹2,600 \times e^{0.12\times0.0833}$ $= ₹2,600 \times e^{0.01}$ $= ₹2,600 \times 1.01005$ $= ₹2,626.13$
3 Months or 3/12Year i.e. 0.25	$F_A = ₹2,600 \times e^{0.09\times0.25}$ $= ₹2,600 \times e^{0.0225}$ $= ₹2,600 \times 1.022755$ $= ₹2659.163$	$F_A = ₹2600 \times e^{0.12\times0.25}$ $= ₹2600 \times e^{0.03}$ $= ₹2600 \times 1.030456$ $= ₹2,679.186$
6 Months or 6/12 i.e. 0.50	$F_A = ₹2,600 \times e^{0.09\times0.50}$ $= ₹2,600 \times e^{0.045}$ $= ₹2,600 \times 1.046028$ $= ₹2,719.673$	$F_A = ₹2600 \times e^{0.12\times0.50}$ $= ₹2600 \times e^{0.06}$ $= ₹2600 \times 1.061837$ $= ₹2,760.776$

(c) FF Ltd.

Period (t)	r = 9% p.a. or 0.09	r = 12% p.a. or 0.12
1 Month or 1/12 year i.e. 0.0833	F_A = ₹600 × $e^{0.09\times0.0833}$ = ₹600 × $e^{0.0075}$ = ₹600 × 1.007528 = ₹604.517	F_A = ₹600 × $e^{0.12\times0.0833}$ = ₹600 × $e^{0.01}$ = ₹600 × 1.01005 = ₹606.03
3 Months or 3/12 Year i.e. 0.25	F_A = ₹600 × $e^{0.09\times0.25}$ = ₹600 × $e^{0.0225}$ = ₹600 × 1.022755 = ₹613.653	F_A = ₹600 × $e^{0.12\times0.25}$ = ₹600 × $e^{0.03}$ = ₹600 × 1.030456 = ₹618.274
6 Months or 6/12 i.e. 0.50	F_A = ₹600 × $e^{0.09\times0.50}$ = ₹600 × $e^{0.045}$ = ₹600 × 1.046028 = ₹627.617	F_A = ₹600 × $e^{0.12\times0.50}$ = ₹600 × $e^{0.06}$ = ₹600 × 1.061837 = ₹637.102

Illustration 9

Shares of Sandeep Ltd. are being quoted at ₹600. 3-Months Futures Contract Rate is ₹ 636 per share for a lot size of 500 shares. If the Sandeep Ltd. Is not expected to distribute any dividend in the interim, risk free rate of return is 9%, what is the recommended course of action for a trader in shares?

If the 3-Months Futures Contract Rate is 600, what should be the action?

Solution:

1. Computation of Theoretical Forward Rate [TFP]

Particulars	Value
Spot Price [S_x]	₹600
Risk Free Interest Rate [r]	9% or 0.09
Period [t]	3 Months or 3/12 yrs i.e. 0.25
Theoretical Forward Rate [TFP_x] = $S_x \times e^{rt}$ = ₹600 × $e^{0.09 \times 0.25}$ = ₹600 × $e^{0.0225}$ = ₹600 × 1.022755	613.653

2. Evaluation and Suggested Course of Action

Particulars	Case A	Case B
3-Months Futures Contract Rate [AFP_x]	₹636	₹600
TFP_x Vs. AFP_x	AFP_x is Higher	AFP_x is Lower
Valuation in Futures Market	Overvalued	Undervalued
Action	Buy Spot. Sell Future	Sell Spot. Buy Future

Illustration 10

Compute the theoretical forward price of the following securities for 2 month, 3 months and 4 months —

Securities of	A Ltd.	B Ltd.	D Ltd.
Spot Price [S_0]	₹4,550	₹360	₹900
Dividend Expected	₹50	₹20	₹50
Dividend Receivable in	2 Months	3 Months	4 Months
6 Month's Futures Contract Rate	₹4600	₹390	₹920

You may assume a risk-free interest rate of 9% p.a.
What action should follow to benefit from futures contract?

Solution:

Securities of	A Ltd.	B Ltd.	D Ltd.
Spot Price [S_0]	₹4,550	₹360	₹900
Dividend Expected [D_F]	₹50	₹20	₹50
Dividend Receivable in [t]	2 Months or 1/6 Year or 0.1667	3 Months or 1/4 Year or 0.25	4 Months or 1/3 year or 0.333
Risk Free Interest Rate [r]	9% or 0.09	9% or 0.09	9% or 0.09
Present Value of Dividend [I]	$D_F \times e^{-rt}$	$D_F \times e^{-rt}$	$D_F \times e^{-rt}$
	$= 50 \times e^{-0.09 \times 0.1667}$	$= 20 \times e^{-0.09 \times 0.25}$	$= 50 \times e^{-0.09 \times 0.333}$
	= ₹49.256	= ₹19.555	= ₹48.522
Adjusted Spot Price [$S_0 - I$]	₹4550 – ₹49.256	₹360 – ₹19.555	₹900 – ₹48.522
	= ₹4500.744	= ₹340.445	= ₹851.478
Theoretical Forward Price [TFP]	$= 4500.744 \times e^{0.09 \times 0.50}$	$= 340.445 \times e^{0.09 \times 0.50}$	$= 851.478 \times e^{0.09 \times 0.50}$
	$= 4500.744 \times e^{0.045}$	$= 340.445 \times e^{0.045}$	$= 851.478 \times e^{0.045}$
	$= 4500.744 \times 1.04603$	$= 340.445 \times 1.04603$	$= 851.478 \times 1.04603$
	= ₹4707.91	= ₹356.312	= ₹890.672
6 Months Futures Contract Rate [AFP]	₹4600	₹390	₹920
TFP Vs. AFP	AFP_X is Lower	AFP_X is Higher	AFP_X is Higher
Valuation in Futures Market	Undervalued	Overvalued	Overvalued
Recommended Action	Sell Spot. Buy Future.	Buy Spot. Sell Future.	Buy Spot. Sell Future.

Illustration 11

A four month European call option on a dividend paying stock is currently selling for ₹5. The stock price is ₹66, the strike price is ₹60, and a dividend of ₹0.80 is expected in one month. The risk free interest rate is 12% per annum for all maturities. Do you have arbitrage?

Solution:

Particulars	Amount
Spot Price [S_0]	₹66
Dividend Expected [D_F]	₹0.80

Dividend Receivable in [t]	1 Month or 1/12 Year or 0.0833
Risk Free Interest Rate [r]	12% or 0.12
Present Value of Dividend [I]	DF × e^{-rt}
	= ₹0.80 × $e^{-0.12\times1/12}$
	= ₹0.80 × $e^{-0.01}$
	= ₹0.80 ÷ 1.01005 = ₹0.7920
Adjusted Spot Price = S_0 – I	₹66 - ₹0.7920 = ₹65.208
Theoretical Forward Price = TFP	= (S_0 – I) e^{rt}
	= 65.208 × $e^{0.12\times4\div12}$
	= 65.208 × $e^{0.04}$
	= 65.208 × 1.0408 = ₹67.868

Illustration 12

The price of Compact Stock of a face value of ₹10 on 31st December, 2024 was ₹414 and the futures price on the same stock on the same date i.e., 31st December, 2024 for March, 2025 was ₹444.

Other features of the contract and the related information are as follows:

- Time to expiration 3 months (0.25 year)
- Annual dividend on the stock of 30% payable before 31.3.2025.
- Borrowing Rate is 20 % p.a.

Based on the above information, calculate future price for Compact Stock on 31st December, 2024. Please also explain whether any arbitrage opportunity exists.

Solution:

Calculation of Future Price

Particulars	Remarks
Spot Price [S_0]	₹414
Expected rate of Dividend [y]	30% or 0.30
Borrowing Rate	20%
Tenor / Time Period [t] in Years	3 Months or 0.25 Year
Present Value of Dividend [I]	= (30% × 10) × $e^{-0.20\times0.25}$
	= (30% × 10) ÷ 1.05127
	= 3 ÷ 1.05127 = 2.8537
Adjusted Spot Price [Spot Price- Present Value of Dividend] [S_0 – I]	= 414 - 2.8537 = ₹ 411.1463
Theoretical Forward Price [TFP] TFP = [S_0 – I] × $e^{(r-y)\times t}$	= ₹411.1463 × $e^{0.20\times0.25}$
	= ₹411.1463 × $e^{0.05}$
	= ₹411.1463 × 1.05127 = ₹432.23
3-Months Futures Contract Rate [AFP]	₹ 444

TFP Vs. AFP	AFP is Higher
Inference	AFP is overvalued
Recommended Action	Buy Spot. Sell Future.

Cash Flows to Gain on the Arbitrage Opportunity

Activity Flow:

(a) Borrow ₹414 for a period of 3 months at the rate of 20% p.a.

(b) Buy the Stock at ₹414 at T_0

(c) Receive the Dividend at the time of 3 months [₹10 × 30% = ₹3].

(d) Sell the Index Futures at the Forward Price at the end of 3 months [₹444].

(e) Repay the amount of Loan with Interest at the end of the period.

Cash Flows arising out of the activities to gain on the Arbitrage:

Sl. No.	Particulars	₹
(a)	Borrow for a period of 3 months and Buy Stock at T_0	414
(b)	Receive the Dividend at the end of 3 months	3
(c)	Sell the Futures at the Forward Price at the end of 3 months	444
(d)	Repay the amount of borrowing together with Interest = [$414 \times e^{0.20 \times 0.25}$]	(435.23)
(e)	Net Cash Inflow [(b + c) – d]	11.77

Illustration 13

Super Polycarbons Ltd. has the following information about LDPE and HDPE granules (raw material used for Manufacturing Plastic films, Polyfilms and Plastic Sheets) –

Stock Item	LDPE Granules	HDPE Granules
Current Market Price i.e. spot price [S_0]	₹75 per Kg	₹85 per Kg
Carrying Cost	4% p.a. [continuous compounding]	₹100 per Quintal per quarter (payable after 2 months)
3-Month's Futures Contract Rate (500 Kgs)	₹38,500	₹44,600

Risk free interest rate is at 12% p.a. Advise Super Polycarbons on the course of action to be taken?

Solution:

1. Evaluation of futures Contract Option for LDPE Granules

Inventory / Commodity	LDPE Granules
Spot Price [S_x]	₹75 per kg
Storage costs [rate] [C]	4% or 0.04

Tenor / time Period [t] in years	3 Months or 0.25 Year
Risk free Interest rate [r]	12% or 0.12
Theoretical Forward Price [TFP_x] per kg $TFP_x = S_x \times e^{(r+c)\times t}$ $= ₹75 \times e^{(0.12+0.04)\times 0.25}$ $= ₹75 \times e^{0.16\times 0.25}$ $= ₹75 \times e^{0.04}$ $= ₹75 \times 1.0408$	₹78.06
TFP_x per lot size of 500kg [500kgs × ₹78.06 per kg]	₹39,030
3-Months Futures Contract rate [AFP_x]	₹38,500
TFP_x Vs. AFP_x	AFP_x is Lower
Valuation is Futures Market	Undervalued
Recommended Action	Buy Future. Sell Spot

2. Evaluation of Futures Contract Option for HDPE Granules

Inventory / Commodity	HDPE Granules
Spot Price [S_x]	₹85 per kg or ₹42,500 per Lot of 500 kgs
Storage Costs [rate] [C] (payable after 2 months)	₹100 per Quintal (i.e. 100 kgs) per quarter or ₹500 per lot of 500 kgs.
Tenor / Time Period [t] in Years	2 Months or 0.1667 Year
Risk Free Interest Rate [r]	12% or 0.12
Present Value of Storage Costs [C_p] $C_F = e^{-rt}$ or $C_F \div e^{rt}$ $= ₹500 \div e^{0.12\times 0.16667}$ $= ₹500 \div e^{0.02}$ $= ₹500 \div 1.0202$	₹490.10
Adjusted Current Spot Price of HDPE Granules S_{Adj} [Spot Price ₹42,500 + Present Value of Storage Costs C_p ₹490.10]	₹42,990.10
Theoretical Forward Price [TFP_x] per kg $TFP_x = S_{Adj} \times e^{rxt}$ $= ₹42,990.10 \times e^{0.12\times 0.25}$ $= ₹42,990.10 \times e^{0.03}$ $= ₹42,990.10 \times 1.03045$	₹44.299.15
3-Months Futures Contract Rate [AFP_x]	₹44,600
TFP_x Vs. AFP_x	AFPx is Higher
Valuation in Futures Market	Overvalued
Recommended Action	Buy Spot. Sell Future

Illustration 14

The following data relates to DCB Ltd's share prices:

Current Price per share	₹170
Prices per share the futures market - 6 months	₹190

It is possible to borrow money in the market for securities transactions at the rate of 12% p.a.

Required –

(a) Calculate the theoretical minimum price of 6 month-futures contract.

(b) Explain if any arbitraging opportunities exist.

Solution:

a. Theoretical Futures Price

Particulars	Value
6-months Futures Price	₹190
Current Stock Price [S_x]	₹170
Borrowing Rate (r)	12% or 0.12
Time (in years)	6/12 = 0.5 year
Theoretical Futures Price [F_x]	$= S_x \times e^{rt}$ $= ₹170 \times e^{0.12 \times 0.5}$ $= ₹170 \times e^{0.06}$ $= ₹170 \times 1.0618$ $= ₹180.506$

Inference: Since the Theoretical Futures Price is less than the Expected Futures Price, the recommended action would be to sell in the Futures Market.

b. Cash Flows to gain from Arbitrage Opportunity Activity Flow:

Arbitrageur can borrow the amount required to buy the shares at the current market price i.e. ₹170 at the rate of 12% p.a. for 6 months

1. Enter into a Futures Contract to sell Shares at the rate of ₹190
2. On the expiry date, sell the shares at the 6-month Futures rate of ₹190.
3. Pay the amount of Borrowing together with Interest i.e. $[170 \times e^{0.12 \times 0.5}] = ₹180.506$.

Particulars	Time	₹
1. Borrow at the rate of 12% for 6 months	T_0	170
2. Enter into a Futures Contract to sell Shares	T_0	-
3. On the expiry Date, sell the shares at 6-months Forward Rate	T_1	190
4. Repay the amount of borrowing together with interest $[170 \times e^{0.12 \times 0.5}] = [170 \times 1.0618]$	T_1	180.506
5. Net Gain made [(3) – (4)]	T_1	9.494

Divergence of Future Price and Spot Price – The Basis

The difference between the futures price and the spot price is known as Basis. In other words,

Basis = Future Price − Spot Price

In a "normal market", the futures price would be greater than the spot price and, therefore, the basis will be positive, while in an "inverted market", the reverse holds. In an inverted market, the basis is negative since the spot price exceeds the futures price in such a market. The futures price is expected to be higher than the spot price because of the carrying costs. However, as the delivery month approaches, the basis declines until the spot and futures prices are approximately the same. This phenomenon is known as convergence.

1. Normal backwardation

2. Contango

3. Expectation principle

Normal Backwardation: According to this hypothesis, the expected basis is negative as the futures price tends to be a downward estimate of its spot price in the cash market at the contract's maturity date.

Contango: This hypothesis assumes the other possibility—the hedgers generally buy the contracts, while the speculators generally sell the contracts. It contends the speculators, because of their knowledge and expertise about the futures market, and the inefficiencies of the market, are largely willing to assume the price risk in anticipation of earning profits. In view of the anticipated profits, they bid up the prices of the commodity contracts, which results in a positive basis.

Expectation Principle: This theory postulates that the expected basis would be equal to zero. This is based on the argument that futures prices are an unbiased estimate of expected future spot prices, as would be expected in an efficient market. Thus, there is no room for any excess returns for either the hedgers or the speculators.

⊙ Hedging through Futures

Hedge means to protect or lock in a value. In order to perform a hedge we need two assets. We need another asset to protect the one which we are holding and for which we are trying to create a hedge.

The behaviour of the two assets is the key in deciding the hedge. The asset chosen to hedge the existing asset can be positively correlated with the existing asset or it can be negatively correlated. If the asset chosen for the purpose of hedging is positively correlated with our existing asset, then we sell the asset else we buy that asset. The reason being when the asset prices fall, both the assets would lose value. In such a scenario, the asset which we have sold would give gains thereby offsetting the loss in the existing asset. On the same lines, when asset prices rise, the asset used for hedging would lose value, since we have sold them and again it would offset the gains of the existing asset. Thus, in both the scenarios, both the assets put together gives us net zero gains. In other words, the existing asset retains its original value i.e., original value is locked.

Hedging is adopted when we believe that the existing assets are likely to lose value and our intention is to protect the existing value. In other words, we expect the unfavourable event to occur. What happens if the original view (i.e., unfavourable event) does not materialize? The hedge does not provide any benefit; it simply locks in a value that existed when the hedge was initiated. Therefore, hedge is not adopted if unfavourable event is not expected to happen. Hedging is not aimed to make gains or reduce losses; it is aimed at locking a value of a commodity, stock or portfolio.

The goal of a hedge transaction is to create a position that, once added to an investor's portfolio, will offset the price risk of another. A hedge can be so constructed that one can have partial protection say to the extent of 50% or 75% etc. In that case we would have only that much protection and in an unfavourable situation we would be losing 50% or 25% respectively.

a. Hedging while having stocks in the portfolio

If a Fund Manager, wishes to hedge a stock or portfolio position with stock futures or index futures, the basic hedging strategy would be to take an equal and opposite position in the futures market. The second pertinent point is to know the extent of hedging required. If 100% hedging is required then, the desired futures position (value) would equal the portfolio or stock position already held; else proportionate value of futures would be sold. Then the last valid point to be remembered is to account for beta of the stock or portfolio that is being hedged. If the stock is hedged using same stock futures, then the beta is irrelevant as both would have same beta. However, if the portfolio/stock is hedged using index futures then beta is relevant, because the portfolio/stock may have beta less or more than that of market (index futures represents market as a whole). In order to ensure the portfolio position is perfectly hedged it is essential to sell beta times the value of index futures position. Here we say that beta is the hedge ratio. A point to note here would be that, if the market rallies, the opportunity to gain from it will be lost but the portfolio can be protected from a market sell-off, which was the original intent.

Example 1: Consider Mr. X, a portfolio manager managing a portfolio (beta 1.5) whose current market value of ₹ 67.50 Crores. It is expected that the markets are likely to correct downwards and hedging needs to be adopted using NIFTY index futures. Currently index futures are quoted at 4500 with each contract underlies 100 units. Let us examine a situation when markets correct 10% down and also a possibility market trend upwards by 10% against the belief of Mr. X. Let us assume that Mr. X hedged 100% of his portfolio. Each NIFTY index contract is worth ₹ 4,500 × 100 = ₹4,50,000. Value of the portfolio is = ₹ 67.50 Crores Value of Index Futures required to be hedged = Beta times value of portfolio = 1.5 × 67.50 Crores = ₹101.25 Crores Number of NIFTY index contracts to be sold (Since we hold (bought) assets, hedging using other asset should be opposite i.e., sell) = 101.25 Crores /450000 = 2250.

	Market Change	Portfolio Gain	Index Futures	Net Gain / Loss
Pessimistic	–10%	1.5 times 10% i.e., 15% fall in portfolio value = –10.125 Crores	10% gain in futures = +10.125 Crores	Nil
Optimistic	+10%	1.5 times 10% i.e., 15% gain in Portfolio value = +10.125 Crores	10% loss in futures = –10.125 Crores	Nil

Had Mr. X hedged only 50% of his portfolio value, the net gain or loss would not be nil. He would have got only 50% of protection in case of market fall. Thus, when market falls by 10%, against his loss of ₹10.125 Crores, he would have gained only ½ of ₹10.125 Crores in the futures market, since he would have hedged only 50%.

b. Hedging while having money in the account

Having money in the account and not investing in stocks, owing to absence of enough research inputs would not make sense, especially if it is known that the market is likely to rally. In such cases it is prudent to buy Index Futures and participate in the rally and liquidate the futures position, once the rally is over or stocks are ready to be purchased. Another advantage is for buying futures; only around 10% of the total value would be deposited as margin, enabling the fund/ person to deploy the balance to earn money market returns. Had the market not rallied he would have bought the stocks cheaper than originally decided.

Example 2: Consider Mr. Y, a portfolio manager who have been informed that there is an inflow of ₹100 Crores in his new scheme launched this month. While his research department is busy in preparation of final list of stocks that can be bought as part of his portfolio, it is learnt that further one month would pass

before the final stock list is provided to Mr.Y. Meanwhile Mr. Y learns that market is set to rally in the next one month. By parking money in cash and money market instruments for one month is not going to help him in a big way as returns are going to be far less as compared to market returns. The best thing Mr. Y can do is to buy Index futures now and ride the rally and sell off at the end of month. By the end of month research department would have prepared the final list. Though the stocks in general would have inched up, the gains from futures would have compensated sufficiently. Stock index futures allow investors to hedge systematic (market) risk. This is desirable for investors attempting to earn the unique part of a stock's return while avoiding market risk. The futures contract helps to protect the portfolio against market fluctuations. Speculators buy or sell futures contracts in an attempt to earn a return. They are willing to assume the risk of price fluctuations, hoping to profit from them.

c. To modify systematic risk

A fund manager can decrease or increase the systematic risk (market risk) of the portfolio by selling or buying appropriate number of index futures, so that the following equation is satisfied:

Original Portfolio Value × Original Beta ± Futures Position = Original Portfolio Value × Desired Beta.

Selling Futures position reduces the overall systematic risk and vice versa. Consider the same example of Mr. X, discussed under Example 1. The portfolio beta is 1.5 and the current market value is ₹67.50 Crores. Since the markets are expected to correct downwards and in such a situation if he wants to reduce beta of his portfolio, he can do so by adding another asset whose beta is lower and have a combined portfolio with lower beta, which will protect him from market fall. Let us assume that Mr. X wants to reduce the beta to 1.00. Two strategies can be adopted. (a) Mr. X can stay in cash (beta = 0) say to the extent of 20%, by selling the stocks, but in times of sudden fall in the market opportunity to sell is seldom available. (b) Mr. X can use NIFTY index futures just enough to bring the overall beta to the desired level. Mr. X would sell index futures to achieve this objective. The following equation would have to be satisfied.

Original Portfolio Value × Original β – Futures Position = Original Portfolio Value × Desired β

= 67.50 Crores × 1.5 – X = 67.50 Crores × 1.0 i.e., X = 33.75 Crores.

This means Mr. X would sell NIFTY index futures worth ₹33.75 Crores, by selling 33.75 Crores / 4.5 lakhs = 750 Contracts.

	Market Change	Portfolio Gain	Index Futures	Net Gain / Loss
Pessimistic	–10%	1.5 times 10% i.e., 15% fall in portfolio value = –10.125 Crores	10% gain in futures = +3.375 Crores	–6.75 Crores*
Optimistic	+10%	1.5 times 10% i.e., 15% gain in portfolio value = + 10.125 Crores	10% loss in futures = –3.375 Crores	+6.75 Crores*

*Had Mr. X's portfolio beta was 1, then his ₹67.50 Crore portfolio would have lost just 10%, with the market fall of 10% and vice versa. A higher beta portfolio has been swiftly turned to the desired beta level by selling appropriate index futures.

Consider another illustration.

Illustration 15

A high net worth individual (Mr. Z) is holding the following portfolio in ₹ Crores:

Investment in diversified equity shares	80.00
Cash and Bank Balances	20.00
Total	100.00

The Beta of the portfolio is 1.2. The index future is selling at 5500 level. Mr. Z wants to reduce the beta of the portfolio, for he believes that the market would go down from the current level. How many index futures he should buy/sell so that the beta is decreased to 0.80? One index future consists of 100 units.

Solution:

One can reduce or increase the systematic risk (market risk) of the asset/ portfolio by selling or buying appropriate number of index futures, so that the following equation is satisfied:

Original Portfolio Value × Original Beta ± Futures Position = Original Portfolio Value × Desired Beta

In this case, since beta has to decrease Mr. Z would go short (sell - by selling Nifty or index futures, we are decreasing the market risk - thus beta overall would fall) the appropriate number of index futures. The formula to calculate the number of contracts can be given by:

$$\text{Number of contracts} = (\beta^* - \beta) \times \frac{\text{Portfolio Value}}{\text{Value of the futures contract}}$$

The portfolio value given is = ₹100 Crores, β = 1.2 and β^* = 0.8 (desired) and each future contract is = 5500 × 100 = ₹5,50,000. Substituting we get, number of contracts for the desired beta of 0.8 as:

$$(0.8 - 1.2) \times 100 \text{ crores}/550000 = -727 \text{ contracts}$$

⊙ Hedge Ratio

A hedger has to decide the number of futures contracts that provide the best hedge for his/her risk profile. The hedge ratio allows the hedger to determine the number of contracts that must be employed in order to minimize the risk of the combined cash-futures position. We can define hedge ratio "as the number of futures contracts to hold for a given position in the underlying asset".

Hr = Futures Position ÷ Underlying asset position.

As explained earlier, for a perfect hedge, in case of a stock/ portfolio position hedged with an index futures position, the hedge ratio is the beta of stock or portfolio. Else, if it is hedged using stock futures position, the hedge ratio is one. If the hedger wants to hedge his stock/ portfolio position partially, then the hedge ratio would be less than one. On the other hand, if his future hedge position is more than that of his current position, we say that the hedge ratio is more than one.

Now, by definition,

$$\beta = \frac{\sigma_{SM}}{\sigma^2_M}$$

We can assume index futures as proxy for markets. We denote index futures as 'F'. Therefore, we have,

$$\beta = \frac{\sigma_{SF}}{\sigma^2_F}$$

$$\text{or, } \beta = \frac{\rho_{SF}\,\sigma_S\,\sigma_F}{\sigma_F}$$

$$\text{or, } \beta = \frac{\rho_{SF}\,\sigma_S}{\sigma_F}$$

or, β = Correlation of underlying with market (i.e., index futures) × proportion of standard deviation of underlying and market.

Accordingly, based on situation, hedge ratio may be equal to, less than or more than the β value.

Consider the following Example.

Example 3

Consider Mr. Y holding an equity portfolio of ₹50 Crores. His portfolio beta is 1.2. He has decided to hedge his portfolio using NIFTY index futures. For various scenarios hedge ratio (as shown in column 2 i.e., Value of futures / Value of underlying) would change as given in the table.

Future s Sold	Value of Futures / Value of the Underlying	% Hedge Adopted	Remarks
₹60 Crores	1.2	100%	Hedge Ratio = Beta of Portfolio
₹30 Crores	0.6	50%	Hedge Ratio ≠ Beta of Portfolio
₹120 Crores	2.4	200%	Hedge Ratio ≠ Beta of Portfolio

⊙ Cross Hedge

Cross Hedge refers to hedging a position in a Stock in the Cash Market, by taking an opposite position in the Futures Market (Derivative Market) in a different stock or index. Cross Hedge concept applies, when the stock to be hedged does not have a Futures Market.

Basis Risk is inherent in a Cross Hedge, i.e., Spot Price of the Commodity and the Futures Price do not converge, because the Commodity for Futures and the Commodity in the Stock market are not the same.

Consider the following example.

Example 4: Ms. A is holding 1000 Shares of KK Software Solutions Ltd, which she wants to sell. She wants to hedge her position by buying KKS Futures. However, KK Software is not traded in the Futures Market. To hedge her position, she can buy Infosys Futures or Wipro Futures or Software Index Futures.

a. Cross-Hedge Ratio

Cross-Hedge Ratio is the same as Hedge Ratio. However, the futures price considered is not of the corresponding stock's future price, but a closely related index or stock.

$$\text{Hedge Ratio} = \frac{\sigma_S}{\sigma_F} \rho_{SF}$$

Where,

σ_S = Standard Deviation of Change in Spot Price of the Asset to be hedged (Eg: KK Software Solutions)

σ_F = Standard Deviation of Change in Futures Price of the Underlying Asset (Eg: Wipro Futures, Infosys Futures etc.)

ρ_{SF} = Correlation between Change in Spot Price of the Asset to be hedged and Futures Price of the Underlying Asset

b. No. of Futures Contract to be Traded

$$\text{No. of Futures Contracts} = \text{Hedge Ratio} \times \frac{\text{Units of spot position requiring hedging}}{\text{No. of units underlying one futures contract}}$$

In Example 4, if the Hedge Ratio is 1.2, and Ms. A wants to cross hedge her position using Software Index Futures (each Index Future contract has 100 Units), then number of contracts required is –

= 1.20 × Shares of KK Software Solution Ltd. (1,000)/ No. of Units in Software Index Future (100)

= 1.20 × 1,000/100 = 12 contracts

c. Choice of Appropriate Cross Hedge Futures

In case of alternatives in the Futures Market in a Cross Hedge situation, the appropriate Futures Contract should be chosen based on the extent of correlation between the asset's price movements and the underlying asset's futures price movements. Higher the correlation, better the choice.

d. Perfect Hedge and Imperfect Hedge

(i) Perfect Hedge: Perfect Hedge is one which completely eliminates the risk. At the time of taking an opposite position in Derivatives Market, Perfect Hedge would mean covering the risk involved in the Cash Market Position completely, i.e., 100%.

(ii) Imperfect Hedge: When the position in cash market is not completely hedged or not hedged to 100%, then such hedge is called Imperfect Hedge.

The hedging strategies using Futures can be summarized in the following diagram.

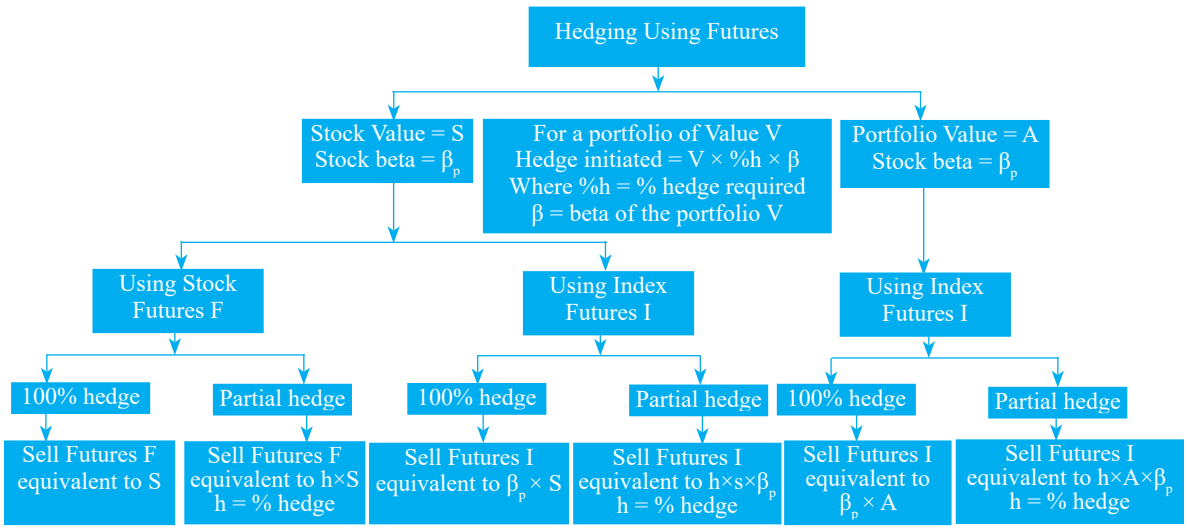


Figure 13.2: Hedging Strategies Using Futures

Consider the following illustrations.

Illustration 16: Cross Hedge

Given the following information

BSE Index	50,000
Value of Portfolio	₹1,01,00,000
Risk Free Interest Rate	9% p.a.
Dividend Yield on Index	6% p.a.
Beta of Portfolio	2.0

We assume that a futures contract on the BSE index with 4 months maturity is used to hedge the value of portfolio

over next 3 months. One future contract is for delivery of 50 times the index. Based on the information, calculate

(a) price of future contract,

(b) The gain on short futures position if index turns out to be 45,000 in 3 months.

Solution:

a. Computation of price of Futures Contract

Securities of	R Ltd.
Spot price [S_x]	₹50,000
Dividend yield Expected [Y]	6% or 0.06
Tenor / Time period [t] in Years	4 Months or 0.3333 Year
Risk Free interest Rate [r]	9% or 0.09
Price of Futures Contract [TFP_x] $TFP_x = S_x \times e^{(r-y)\times t}$	$= ₹50,000 \times e^{(0.09 - 0.06) \times 0.3333}$ $= ₹ 50,000 \times e^{0.03\times0.3333}$ $= ₹50,000 \times e^{0.01}$ $= ₹50,000 \times 1.0101$ $= ₹50,505$

Therefore, price of the Futures Contract is ₹50,505 or ₹50,500 (Approx)

b. Gain on short Futures Position

(i) Computation of No. of Contracts to be entered into:

Particulars	Value
Portfolio Value	₹1,01,00,000
4-Month's futures Price per Unit of BSE Index	₹50,500
No. of Units per BSE Index Futures Contract	50
Value per BSE Index futures Contract [50 Units × 50,500 per unit]	₹25,25,000
No. of Contract to be entered [Portfolio Value × Beta of Portfolio w.r.t Index ÷ Value per BSE Index futures Contract] = [₹1,01,00,000 × 2.0 ÷ ₹25,25,000]	8 Contracts

(ii) Computation of Gain on Short Futures Position

Particulars	Value
Position	SELL
Contracted Sale Price per Unit of BSE Index	₹50,500
Less: Index Position in 3-Months	₹45,000
Gain per Unit of BSE Index Future	₹5,500
No. of Units per Contract	50
Gain per Contract [₹5,500 × 50 Units]	₹2,75,000
No. of Contract entered into	8

Total Gain [8 Contracts × ₹2,75,000 per contract]	₹22,00,000

Total Gain on Short Futures Position in 3 Months is ₹22,00,000

Illustration 17

Hedging of risks – Futures Rate Not Available - Choice of Cross Hedge.

Bharat Investments Ltd is long on 25,000 shares of Trinayan Earth Moving Equipment Ltd (TEEL). Its shares are currently quoted at ₹180 per share. Bharat fears fall in prices of TEEL. It therefore wants to hedge its risk under the Futures Contract route. However, future rate is not available for TEEL. Therefore, Bharat is looking for cross hedge and the following particulars are made available -

Related index	NIFTY	Infrastructure Index	Iron and Steel Index	Bank Index
Beta of TEEL Related Index	0.8	1.1	1.3	1.0
Correlation of TEEL with Related Index	0.6	0.8	0.6	0.3
No. of Units of TEEL underlying every Futures Contract of Index	1000	500	1000	1250

Bharat contemplating taking a cross hedge in either Iron and Steel Index, because it has the highest Beta value. Consequently requiring less no. of Futures Contract or Bank Index as it has the perfect Beta Value.

Advice Bharat

Solution:

1. Choice of Index for Cross Hedge

(a) Basis / Reasoning:

- **Object of Hedging:** Hedging through Futures Contract is done to mitigate or eliminate price related risks. The object is to eliminate uncertainty about the future price movements and freeze the impact of price movement at a particular point.
- **Relevance of Beta Value:**
  - (i) Beta value is the sensitivity of the stock to be hedged (TEEL) to the changes in value of the indices. It is an indication of volatility of the stock with reference to the movement in index.
  - (ii) It is also equal to the number of units of Index Future required to hedge one unit of the stock.
  - (iii) High Beta or Low Beta value is not the sale factor determining the choice of a cross hedge. If however, transaction costs are high, and a low beta index may be preferred.
- **Correlation:** Choice of the perfect cross hedge should be based on the correlation between the price of the stock to be hedged and the index used as a cross hedge. Higher the correlation with the index, better the index for cross hedging.
- **Beta vs. correlation:**
  - (i) An index which is highly correlated with stock to be hedged should be preferred over an index with a lower correlation.

(ii) Where two indexes carry the same Beta Index, one with the higher correlation should be preferred.

(iii) Where two index carry the same correlation, index with a lower Beta may be preferred.

(b) Evaluation of Different Indices

Related Index [I]	NIFTY	Infrastructure Index	Iron and Steel Index	Bank Index
Beta of TEEL [β_{TL}]	0.8	1.1	1.3	1.0
Correlation of TEEL [ρ_{TL}]	0.6	0.8	0.6	0.3
No. of Units of TEEL underlying every Futures Contract of Index	1000	500	1000	1250
Ranking based on Correlation [Most correlated Index]	2	1	3	4

Note: NIFTY vs. Iron and Steel Index: Though both have the same correlation, Beta W.r.t NIFTY is nearer to 1 than beta w.r.t to Iron and Steel Index. Therefore, NIFTY edges over Iron and Steel Index.

Conclusion: Therefore, Bharat Investments should prefer to cross hedge using Infrastructure Index.

2. Course of Action

i. Basis: Bharat is long in the cash market i.e. buy in the cash market. Therefore, it should take the opposite position in the Futures Market of Infrastructure Index.

ii. Activity: It should sell Infrastructure Index Futures. Therefore it should enter into Futures Contract for selling Infrastructure Index Futures after a specified period.

iii. No. of contracts: No. of Infrastructure Contracts to be sold

$$= \text{Hedge Ratio} \times \frac{\text{Units of spot position requiring hedging}}{\text{Units in one Futures Contract of Infra Index}}$$

$$= \text{Hedge Ratio [Beta of Changes in price w.r.t Infra Index]} \times \frac{\text{Units of TEEL required by Trinayan}}{\text{Units in one Future Contract of Infra Index}}$$

$= 1.10 \times 25000 \text{ Units} \div 1000 \text{ Units}$

$= 1.10 \times 25 = 27.5$ Future Contracts

Bharat should sell 27.5 Infrastructure Index Futures.

Illustration 18

In February, Pepper future traded at 16.80, the February ₹18.00 call at ₹0.45 and the February ₹18.00 put at ₹0.58. both are options on the February future. Find out whether any arbitrage opportunity exists.

Solution:

(a) Cost of future = ₹16.80

(b) Cost of Pepper = Present Value of Exercise Price + Value of Call – Value of put = ₹18 + ₹0.45 – ₹0.58 = ₹17.87

(c) Conclusion: Since there is difference between spot price and Futures price. Arbitrage opportunity exists.

Illustration 19: Stock Index – Futures

A portfolio manager owns 3 stocks

Stock	Shares owned	Stock price (₹)	Beta
1	2 lakh	800	1.1
2	4 lakh	600	1.2
3	6 lakh	200	1.3

The spot Nifty Index is at 2700 and futures price is 2704. Use stock index future to (a) decrease the portfolio beta to 0.8 and (b) Increase the portfolio beta to 1.5. Assume the index factor is ₹100. find out the number of contracts to be bought or sold of stock index futures.

Solution:

Computation of existing Portfolio Beta

Security	Market value of security (₹ Lakhs)	Proportion	Beta of the Security	Weighted Beta
1	1,600	4/13	1.1	0.34
2	2,400	6/13	1.2	0.55
3	1,200	3/13	1.3	0.30
	5,200			1.19

Value per Futures Contract

= Index Price per unit × Lot Size per Futures Contract

= ₹2700 × 100 = ₹2,70,000

a. Activity to Reduce Portfolio Beta to 0.8

(i) Object: Reduce portfolio Beta

(ii) Activity: Sell Index Futures

- Beta of Existing Portfolio = $\beta_I = 1.19$
- Desired beta of the New Portfolio = $\beta_N = 0.8$
- Contract Size = 100 units
- Value per Futures Contract in NIFTY = V_F = ₹2,700 × 100 = ₹2,70,000
- Value of the portfolio = V_P = ₹5,200 Lakhs
- No. of Futures contract to be sold:

$$= \text{Portfolio Value} \times \frac{[\text{Beta of the Portfolio} - \text{Desired Value of Beta}]}{\text{Value of a Futures Contract}}$$

$$= V_P \times \frac{\beta_I - \beta_N}{V_F}$$

= ₹5,200 Lakhs × [(1.19 − 0.8) ÷ ₹2,70,000] = 751 Contracts

b. Activity to Increase the portfolio Beta to 1.5

(i) Object : Increase portfolio Beta

(ii) Activity: Buy Index futures

- Beta of Existing portfolio = $\beta_I = 1.19$
- Desired Beta of the New portfolio = $\beta_N = 1.5$
- Value per Futures contract in NIFTY = V_F = ₹2,700 × 100 = ₹2,70,000
- Value of the portfolio = V_P = ₹5,200 Lakhs
- No of futures Contract to be bought:
- = Portfolio Value × $\frac{[\text{Desired Value of Beta} - \text{Beta of the Portfolio}]}{\text{Value of a Futures Contract}}$

$$= V_P \times \frac{\beta_N - \beta_I}{V_F}$$

= ₹5,200 Lakhs × [(1.50 – 1.19) ÷ ₹2,70,000] = 597 Contracts

Illustration 20: Headging with Index Futures

A Unit trust wants to hedge its portfolios of shares worth ₹10 million using the BSE-Sensex index futures. The contract size is 100 times the index. The index is currently quoted at 6,840. The beta of the portfolio is 0.8. the beta of the index may be taken as 1. What is the number of contracts to be traded?

Solution:

- Beta of Portfolio = $\beta_1 = 0.8$
- Beta of Index = $B_N = 1$
- Value per futures contract V_F = ₹6,840 × 100 = ₹6.84 Lakhs
- Value of the portfolio = V_P = ₹100 Lakhs
- Hedge Ratio = Beta of the portfolio ÷ Beta of the Index = 0.8 ÷1 = 0.8
- No. of Futures Contract to be traded:

  $= \text{Portfolio Value} \times \frac{\text{Hedge Ratio}}{\text{Value of a Futures Contract}}$

  $= V_P \times \frac{\text{Hedge Ratio}}{V_F}$

  = ₹100 Lakhs × [0.8 ÷ 6.84 Lakhs] = 11.70 i.e. 12 Contracts

Illustration 21

Which position on the index future gives a speculator, a complete hedge against the following transitions:

(a) The share of Yes Limited is going to rise. He has a long position on the cash market of ₹100 Lakhs on the Yes Limited. The beta of the Yes Limited is 1.25.

(b) The share of No Limited is going to depreciate. He has a short position on the cash market of ₹50 Lakhs on the No Limited. The beta of the No Limited is 0.90

(c) The share of Fair Limited is going to stagnant. He has short position on the cash market of ₹40 Lakhs of the Fair Limited. The beta of the Fair Limited is 0.75.

Solution:

1. Value to be traded in Futures [Index Value] = Hedge Ratio × Amount of Portfolio
2. Principles for deciding the Position on Index Futures [Opposite Position in relation to Stock]

Expectation on Stock Price	Action in Stock Market	Position in Index Futures
Rise	Buy / Long	Sell/Short
Fall	Sell/Short	Buy/Long

3. **Position on the Index Futures**

Sl. No.	Co.	Trend	Amount(₹)	Beta /Hedge Ratio	Index Value (₹)	Position
(a)	Yes Ltd.	Rise	100 Lakhs	1.25	1,25,00,000 [100 Lakhs × 1.25]	Short
(b)	No Ltd.	Depreciate	50 Lakhs	0.90	45,00,000 [50 Lakhs × 0.90]	Long
(c)	Fair Ltd.	Stagnant	40 Lakhs	0.75	30,00,000 [40 Lakhs × 0.75]	Long

Illustration 22

Fill up the blanks in the following matrix-

Case	Portfolio Value	Existing Beta	Outlook	Activity	Desired Beta	No. of Futures Contacts
M	?	1.20	Bullish	?	1.8	90
N	₹3,60,00,000	?	?	Buy Index Futures	2.3	45
O	₹2,00,00,000	1.60	?	?	1.2	?
P	₹6,40,00,000	1.10	Bullish	?	?	48
Q	₹2,50,00,000	1.40	Bearish	?	1	?
R	₹5,00,00,000	?	Bearish	Sell Index Futures	1.25	45

S&P index is quoted at 4000 and the lot size is 100.

Solution:

Case	Portfolio Value	Existing Beta	Outlook	Activity	Desired Beta	No. of Futures Contracts
M	₹6,00,00,000	1.20	Bullish	Buy Index Futures	1.8	90
N	₹3,60,00,000	1.80	Bullish	Buy Index Futures	2.3	45
O	₹2,00,00,000	1.60	Bearish	Sell Index Futures	1.2	20
P	₹6,40,00,000	1.10	Bullish	Buy Index Futures	1.4	48
Q	₹2,50,00,000	1.40	Bearish	Sell Index Futures	1	25
R	₹5,00,00,000	?	Bullish	Sell Index Futures	1.25	45

Value per Futures Contract = Index Price per Unit × Lot Size per Futures Contract = ₹ 4000 × 100 = ₹4 Lakhs

1. Case M

(a) Inference: Outlook is Bullish and the desired Beta is more than the existing Beta. Therefore, Index Futures Contract should be bought.

(b) Number of Futures Contract = Portfolio Value × $\frac{\text{Desired Value of Beta – Beta of the Portfolio}}{\text{Value of a Futures Contract}}$

$\rightarrow N_F = V_p \times \frac{\beta_N - \beta_E}{V_F}$

$\rightarrow 90 = V_p \times (1.80 - 1.20) / ₹4 \text{ Lakhs}$

$\rightarrow 0.60\ V_p = 90 \times ₹4 \text{ Lakhs}$

$\rightarrow V_p = ₹3.60 \text{ Crores} \div 0.60 = ₹600 \text{ Lakhs.}$

2. Case N

(a) Inference: Activity is to Buy Index Futures. Therefore, outlook is bullish. Therefore, existing Beta should be lower

(b) Number of Futures Contract = Portfolio Value × $\frac{\text{Desired Value of Beta – Beta of the Portfolio}}{\text{Value of a Futures Contract}}$

$\rightarrow N_F = V_p \times \frac{\beta_N - \beta_E}{V_F}$

$\rightarrow 45 = ₹3.60 \text{ Cr.} \times (2.30 - \beta_E) \div ₹4 \text{ Lakhs}$

$\rightarrow 45 \times ₹4 \text{ Lakhs} = ₹3.60 \text{ Cr.} \times (2.30 - \beta_E)$

$\rightarrow 2.30 - \beta_E = ₹1.80 \text{ Crores} \div ₹3.60 \text{ Crores}$

$\rightarrow 2.30 - \beta_E = 0.50$

$\rightarrow \beta_E = 2.30 - 0.50 = 1.80$

3. Case O

(a) Inference: Desired Beta is lower than existing Beta. Therefore, Outlook is bearish and apt activity is to sell index futures.

(b) Number of Futures Contract = Portfolio Value $\times \frac{\text{[Beta of the Portfolio – Desired Value of Beta]}}{\text{Value of a Futures Contract}}$

$\rightarrow N_F = V_p \times \frac{\beta_E - \beta_N}{V_F}$

$\rightarrow N_F$ = ₹2.00 Cr. × (1.60 – 1.20)/₹4 Lakhs

$\rightarrow N_F$ = ₹2.00 Cr. × 0.40/₹4 lakhs

$\rightarrow N_F$ = ₹80 Lakhs/₹4 Lakhs = 20 contracts

4. Case P

(a) Inference: Desired Beta is lower than existing Beta. Therefore, Outlook is bearish and apt activity is to buy index futures.

(b) Number of Futures Contract = Portfolio Value $\times \frac{\text{Desired Value of Beta – Beta of the Portfolio}}{\text{Value of a Futures Contract}}$

$\rightarrow N_F = V_p \times \frac{\beta_N - \beta_E}{V_F}$

$\rightarrow 48$ = ₹6.40 Cr. × (β_N – 1.10) / ₹4 Lakhs

$\rightarrow 48 = 1.60 \times (\beta_N - 1.10)$

$\rightarrow 48/160 = \beta_N - 1.10$

$\rightarrow 0.30 = \beta_N - 1.10$

$\rightarrow \beta_N = 1.10 + 0.30 = 1.40$

5. Case Q

(a) Inference: Desired Beta is lower than existing Beta. Therefore, apt activity is to sell index futures.

(b) Number of Futures Contract = Portfolio Value $\times \frac{\text{[Beta of the Portfolio – Desired Value of Beta]}}{\text{Value of a Futures Contract}}$

$\rightarrow N_F = V_p \times \frac{\beta_E - \beta_N}{V_F}$

$\rightarrow N_F$ = ₹2.50 Cr. × (1.40 – 1.00) / ₹4 Lakhs

$\rightarrow N_F$ = ₹2.50 Cr. × 0.40 / ₹4 Lakhs

$\rightarrow N_F$ = ₹1 Cr. / ₹4 Lakhs = 25 Contracts

6. Case R

(a) Inference: Outlook is bearish and the activity is to sell Index Futures. Therefore, Existing Beta should be higher than desired Beta.

(b) Number of Futures Contract = Portfolio Value $\times \frac{\text{[Beta of the Portfolio – Desired Value of Beta]}}{\text{Value of a Futures Contract}}$

$\rightarrow N_F = V_p \times \frac{\beta_E - \beta_N}{V_F}$

$\rightarrow 45$ = ₹5 Cr. × (β_E – 1.25) / ₹4 Lakhs

$\rightarrow 45 = 125 \times (\beta_E - 1.25)$

$\rightarrow \beta_E - 1.25 = 45/125$

$\rightarrow \beta_E - 1.25 = 0.36$

$\rightarrow \beta_E = 0.36 + 1.25 = 1.61.$

Options

13.3

13.3.1 Meaning, Features and Types of Options, Option vs. Forward and Futures, Profitability of Option, Profit Profile of Buyer and Seller, Value of Option, Determination of Option Premium

⊙ Concept of an Option

An option is a contractual agreement to buy or to sell a specified amount of the underlying asset at a future specified date at a pre-determined rate where the option buyer has the right, but not the obligation to execute the contract. Upon exercise of the right by the option holder, an option seller is obligated to deliver the specified instrument at the specified price.

⊙ Features of an Option

The important features of options are as follows:

a. The buyer has the right to buy or sell the asset. The seller, on the other hand, has a potential commitment to sell or buy the asset if the buyer exercises his right on the option.

b. To acquire the right of an option, the buyer of the option must pay a price to the seller. This is called the option price or the premium. Option premium is payable even if the option is not exercised.

c. The price at which an option is exercised i.e., the underlying asset is bought or sold, is called the Exercise Price or the Strike Price. The exercise price is determined at the time of entering into the option contract.

d. The option is to be exercised on a future specified date known as the expiry of the option.

e. In case of exchange traded options, the contract size is specified and not negotiable.

f. Each option has a pre-determined tenure (1 month, 3 months etc.).

⊙ Features of an Exchange Traded Option

Though option contracts can be 'over-the-counter' contracts which are tailor made or negotiated, options are normally exchange traded. In other words, options are traded in recognized stock exchanges which act like an intermediary. An exchange traded contract is standardized in terms of the features mentioned earlier. The specification may be discussed as follows.

a. Strike Price / Exercise Price is fixed by the Stock Exchange, and not by the Writer or Holder of an option. The Stock Exchange fixes a series of prices spaced at appropriate price intervals for an underlying asset. An investor can choose his preferred Strike Price from such a range of prices.

For example, the Strike Prices for June 2022 options on shares of Reliance on NSE expiring on 30.06.2022 are available as —₹2,520, ₹2,540, ₹2560, ₹2580, ₹2,600, ₹2,620 etc. An investor can choose to buy an option with an Exercise Price of ₹2,600, while another might choose ₹2,540.

b. Premium is the price at which the options contracts for an asset with a given expiry date and strike price is traded. It is paid by the Buyer to the Writer / Seller of the option. The writer keeps the premium whether or not the option is exercised. In an exchange traded contract, option premium is market determined, i.e., based on the demand for the options with a given strike price. Premium payable on an options contract depends upon various factors like Strike Price, Expiry Date, price of the underlying in the spot market etc.

c. Expiry date in an exchange traded options contract is also exchange determined. Generally, options contract on any security is traded based on its strike price and the expiry date.

For example, in June 2022, the following two option contracts on shares of Reliance on NSE with Strike Price of ₹2,620 are available: Expiry on 30.06.2022 and 28.07.2022.

d. The contract size is also standardized in case of exchange traded options. For example, the stock option on the shares of Reliance on NSE has a lot size of 250 shares. So, one option contract will be of 250 shares of Reliance.

⊙ Forward vs. Futures vs. Options

The distinguishing feature of options vis-à-vis forward and futures is the 'right but not the obligation' clause. In other words, futures and forwards create obligations for both the buyer as well as the seller. However, option contracts provide the buyer the right but not the obligation to execute the contract and hence, in case of an unfavorable situation (where option holder/buyer is incurring losses on exercise the contract), the buyer may simply not execute the contract and avoid the loss. The option seller, however, does not have any right to refuse execution of the contract.

Other differences between Forwards, Futures and Options (exchange traded)[1] are listed below.

Aspect	Forward Contracts	Futures Contracts	Option Contracts
Trading Place	No specific place. Can be traded like any commodity.	Traded on Stock Exchanges.	Traded on Stock Exchanges.
Settlement/ Cash Flow	At the time of delivery of asset, i.e., at the end of the contract period.	Profit/Loss is settled on a daily basis based on movement in Current Futures Price.	Option writer collects premium at the inception of the contract.
Closure of Contract	Delivery is must.	Possible exit routes are: • Physical Delivery • Payment of price differential • Taking an opposite position, and cancelling out the contract.	Possible exit routes are: • Physical Delivery • Payment of price differential • Taking an opposite position, and canceling out the contract.
Price Fixation	Negotiated between parties to the contract.	Determined by the market forces i.e., based on Demand and Supply.	Exercise Price / Strike Price is fixed by the Stock Exchange. Premium is market determined.
Nature	Contracts are not standardized. These are customized.	Contracts are standardized.	Contracts are standardized.

Obligation to Perform	Both parties are under obligation to perform.	Both parties are under obligation to perform.	Only the Writer / Seller of the option is under obligation to perform.
Timing	Contracts can be entered into for any period at any time.	Exchange would fix the expiry date. Contracts can be entered into any time for periods up to the expiry date for that contract.	Exchange would fix the expiry date. Contracts can be entered into any time for periods up to the expiry date for that contract.
Guarantee of Performance	Performance is not guaranteed. There is liquidity risk and counterparty risk.	Stock Exchange will ensure performance. There is little or no liquidity risk and counterparty risk.	Stock Exchange will ensure performance. There is little no liquidity risk and counterparty risk.

⊙ **Advantages and Disadvantages of Options**

The advantages and disadvantages of option contracts are as follows:

Feature	Advantage	Disadvantage	Effect on Holder/ Writer
Cost	Options are an inexpensive way to gain access to the underlying investment without having to buy stock.	As a form of insurance, an option contract may expire worthless. The greater the extent to which the option is out of the money and the shorter the time until expiration, the higher is the risk.	Holder may be disadvantaged due to expiry. Writer would be advantaged as he/she needs not make delivery once the option has expired.
Leverage	Options enable investors to stump up less money and obtain additional gain.	Investors should realize that options' leverage can impact performance on the down side as well.	Writers of naked calls[2] are exposed to unlimited risk.
Marketability	Options trade on an exchange and as such are standardized.	Regulatory intervention can prevent exercise which may not be desirable.	Both parties to an options transaction benefit from standardized and enforceable terms.
Hedging	Options may be used to limit losses.	The investor may end up being incorrect as to the direction and timing of a stock's price and may implement a less than perfect hedge.	Both the holder and the writer may be (dis)advantaged depending upon which side of the trade they assume and the ultimate direction of the underlying security.
Return enhancement	Options may be used to enhance a portfolio's return.	The investor may end up being incorrect as to the direction and timing of a stock's price, rendering the attempt at enhanced portfolio return worthless.	Both the holder and the writer may be (dis)advantaged depending upon which side of the trade they assume and the ultimate direction of the underlying security.

Diversification	One can replicate an actual stock portfolio with the options on those very stocks.	Diversification cannot eliminate systematic risk.	
Regulation	Terms of listed options are regulated.	Restrictions upon exercise may occur by regulatory fiat (OCC, SEC, court, other regulatory agency).	While in some cases necessary, regulatory fiat can disrupt what may be a profitable trade, affecting holder and writer alike.

⊙ Parties to an Option

An option contract has two parties associated with it – buyer or holder and seller.

A buyer or holder of an option is the person who has agreed to buy or sell the underlying at a specified rate (Strike Price) on a future date.

On the other hand, a seller or writer of an option is a person who has agreed to sell or buy the underlying as per the option in case the holder of the option exercises his option.

⊙ Types of Options

Option contracts may be classified based on nature, possibility to exercise before the expiry date and underlying assets as follows:

A. Based on Nature

Based on nature, options can be either Call Option or Put Option.

Call Option	Put Option
Option which gives the holder the right to BUY an asset, but not an obligation to buy.	Option which gives the holder the right to SELL an asset, but not an obligation to sell.
Seller / Writer is under an obligation to sell the underlying asset if the Buyer exercises his option to buy the shares/ stock.	Seller/Writer is under an obligation to buy the underlying asset if the Buyer exercises his option to sell his shares/ stock.

B. Based on the possibility to exercise before the expiry date

Based on the possibility to exercise before the expiry date, options can be either American Option or European Option.

American Option	European Option
Option under which holder can exercise his right at any time before expiry date.	Option under which holder can exercise his right only on the expiry date.

C. Based on the underlying assets

Based on the underlying asset, options can be of following types –

a. **Stock Options:** Here the underlying is an individual stock.

b. **Index Options:** Here the underlying is any index like Nifty 50.

c. **Currency Options:** Here the underlying is any foreign exchange.

d. **Interest Rate Options:** Here, the underlying is the interest rate itself.

⊙ Profitability of an Option Contract

From the perspective of an option buyer, there can be the following three positions of an option contract –

a. **In the Money (ITM) Option:** It is a situation where exercising the option would be advantageous and will result in gain or profit for the option buyer.

b. **At the Money (ATM) Option:** It is a situation where exercising the option would neither result in any profit nor any loss to the option buyer.

c. **Out of the Money (OTM) Option:** It is a situation where exercising the option would result into a loss to the option buyer.

Since, options can be either Call Option or Put Option, the above three positions can be explained with respect to the two types of options as follows:

[Let Spot Price = S_T and Exercise Price = X]

Situation	Call Option		
	Position	**Action**	**Resulting Profit/Loss**
$S_T < X$	Out-of-the-money	Option will not be exercised.	Loss will be equal to the call premium already paid
$S_T = X$	At-the-money	Option buyer will be indifferent	Loss will be equal to the call premium already paid
$S_T > X$	In-the-money	Option will be exercised.	$(S_T - X) - C$
Situation	**Put Option**		
	Position	**Action**	**Resulting Profit/Loss**
$S_T > X$	Out-of-the-money	Option will be exercised.	Loss will be equal to the put premium already paid
$S_T = X$	At-the-money	Option buyer will be indifferent	Loss will be equal to the put premium already paid
$S_T < X$	In-the-money	Option will not be exercised.	$(X - S_T) - P$

Note: Here, C = Call Premium and P = Put Premium

Further, under an in-the-money position, an option buyer may have partial recovery of premium when the difference between the spot price and exercise price is lower than the premium already paid. He may get a net profit when the spot price and exercise price is higher than the premium already paid. Finally, he attains a break-even when the spot price and exercise price is exactly equal to the premium already paid.

Thus, for a Call Option, the Break-even Price = X + C and for a put option, the Break-even Price = X – P.

Accordingly, the risk of an option buyer (call or put) is limited to the premium paid on the contract as when exercising the option is not advantageous, he loses only the premium paid. At this situation, the option seller's profit is equal to the premium. However, when an in-the-money option is exercised the profit potential of the buyer is unlimited while the potential loss of the option seller is also unlimited.

Illustration 23

On 29.06.2022, a trader buys a July 28, 2022 European Call Option on Reliance shares with a strike price of ₹2,620 at ₹330. Determine his profit or loss if the spot price of shares prevailing on expiry is ₹2390, ₹2620, ₹2,850, ₹2950, ₹3050. Also determine the break-even price.

Solution:

Calculation of Profit or Loss of the Call Option Buyer

Expected Spot Price (S_T) (₹)	Exercise Price (X) (₹)	Premium (C) (₹)	Position	Gross gain (₹) = (S_T -X)	Net Profit (₹) = (S_T -X) - C
2,390	2,620	330	Out of the Money	---	---
2,620	2,620	330	At the Money	---	---
2,850	2,620	330	In the Money	230	–100
2,950	2,620	330	In the Money	330	Nil
3,050	2,620	330	In the Money	430	+100

The break-even price = X + C = 2,620 + 330 = ₹2,950

Illustration 24

On 29.06.2022, a trader buys a July 28, 2022 European Put Option on Infosys shares with a strike price of ₹1,380 at ₹25. Determine his profit or loss if the spot price of shares prevailing on expiry is ₹1,410, ₹1,380, ₹1,360, ₹1,355, ₹1,345. Also determine the break-even price.

Solution:

Calculation of Profit or Loss of the Put Option Buyer

Expected Spot Price (S_T) (₹)	Exercise Price (X) (₹)	Premium (C) (₹)	Position	Gross gain (₹) = (X - S_T)	Net Profit (₹) = (X - S_T) - P
1,410	1,380	25	Out of the Money	---	---
1,380	1,380	25	At the Money	---	---
1,360	1,380	25	In the Money	20	– 5
1,355	1,380	25	In the Money	25	Nil
1,345	1,380	25	In the Money	35	+10

The break-even price = X − P = 1,380 − 25 = ₹1,355

⊙ Profit Profile of Option Buyer and Option Writer

In financial derivatives terminology, we often use two terms – 'long' and 'short'. Long position with respect to an asset or a derivative contract means that the person has bought the asset/contract while short position with respect to an asset or a derivative contract means that the person has sold the asset/contract. Accordingly, in option trading, there may be following four basic positions:

A. Long Call: It refers to a position where a person has bought a call option and paid the premium. Generally, an option trader buys a call when he expects the price of the underlying asset to increase in future.

Consider the following illustration.

Illustration 25

Mr. A buys a July call option with a strike price of ₹3,500 at ₹50. Show his profit profile at alternative spot prices on expiration.

Solution:

Calculation of net profit

Spot Price (₹)	Strike Price (₹)	Premium (i.e., Price) (₹)	Status	Net Payoff (₹)
3,000	3,500	50	OTM	(–) 50
3,400	3,500	50	OTM	(–) 50
3,500	3,500	50	ATM	(–) 50
3,520	3,500	50	ITM	(–) 30
3,550	3,500	50	ITM	Nil (BEP)
3,600	3,500	50	ITM	+ 50

Note: OTM = Out of the Money; ATM = At the Money; ITM = In the Money

Thus, the maximum possible loss of the option buyer = ₹50 while his profit potential is unlimited. BEP = Strike Price + Premium = 3,500 + 50 = ₹3,550

The graph of the long call will be as follows:

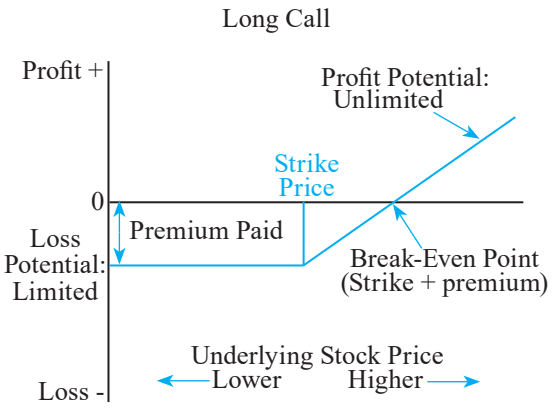


Figure 13.3: Payoff Profile for Long Call

B. Short Call: It refers to a position where a person has written a call option and received the premium. Generally, an option trader writes a call option when he expects the price of the underlying asset to decrease in future or remain unchanged. When he writes a call option without owning the underlying asset, it is called a naked call.

Consider the following illustration.

Illustration 26

Mr. B writes a July call option with a strike price of ₹3,500 at ₹50. Show his profit profile at alternative spot prices on expiration.

Solution:

Calculation of net profit

Spot Price (₹)	Strike Price (₹)	Premium (i.e., Price) (₹)	Status	Net Payoff (₹)
3,000	3,500	50	OTM	+ 50
3,400	3,500	50	OTM	+ 50
3,500	3,500	50	ATM	+ 50
3,520	3,500	50	ITM	+ 30
3,550	3,500	50	ITM	Nil (BEP)
3,600	3,500	50	ITM	(–) 50

Thus, the maximum possible gain of the option writer = ₹50 while his loss potential is unlimited.

The graphical representation of a short call payoff profile will be as follows.

Short Call

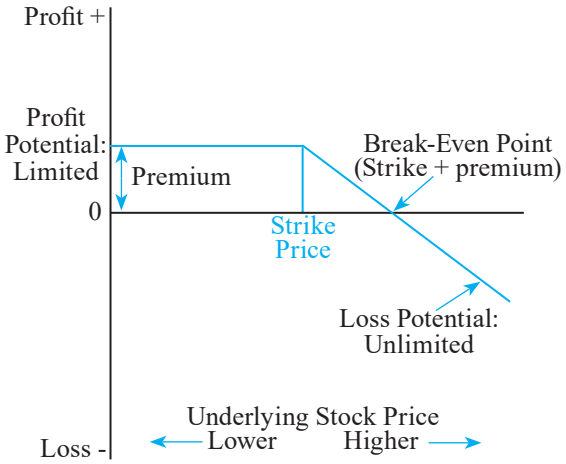


Figure 13.4: Payoff Profile for Short Call

C. **Long Put:** It refers to a position where a person has bought a put option and paid the premium. Generally, an option trader buys a put option when he expects the price of the underlying asset to decrease in future.

Consider the following illustration.

Illustration 27

Mr. C buys a July put option with a strike price of ₹3,500 at ₹50. Show his profit profile at alternative spot prices on expiration.

Solution:

Calculation of net profit

Spot Price (₹)	Strike Price (₹)	Premium (i.e., Price) (₹)	Status	Net Payoff (₹)
3,700	3,500	50	OTM	(–) 50
3,600	3,500	50	OTM	(–) 50
3,500	3,500	50	ATM	(–) 50
3,480	3,500	50	ITM	(–) 30
3,450	3,500	50	ITM	Nil (BEP)
3,400	3,500	50	ITM	+ 50

Thus, the maximum possible loss of the option buyer = ₹50 while his profit potential is unlimited.

BEP = Strike Price - Premium = 3,500 − 50 = ₹3,450.

The graphical representation of a long put payoff profile will be as follows.

Long Put

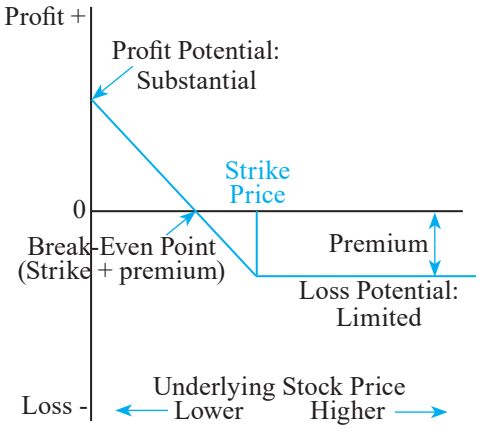


Figure 13.5: Payoff Profile for Long Put

D. Short Put: It refers to a position where a person has written a put option and received the premium. Generally, an option trader writes a put option when he expects the price of the underlying asset to increase in future.

Consider the following illustration.

Illustration 28

Mr. D writes a July put option with a strike price of ₹3,500 at ₹50. Show his profit profile at alternative spot prices on expiration.

Solution:

Calculation of net profit

Spot Price (₹)	Strike Price (₹)	Premium (i.e., Price) (₹)	Status	Net Payoff (₹)
3,400	3,500	50	OTM	(–) 50
3,450	3,500	50	OTM	Nil (BEP)
3,480	3,500	50	ATM	+ 30
3,500	3,500	50	ITM	+ 50
3,600	3,500	50	ITM	+ 50
3,700	3,500	50	ITM	+ 50

Thus, the maximum possible gain of the option writer = ₹50 while his loss potential is unlimited.

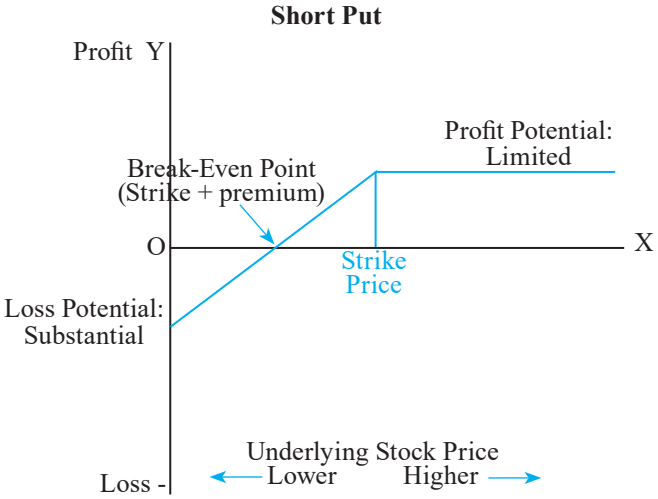


Figure 13.6: Payoff Profile of Short Put

⊙ Intrinsic Value and Time Value of an Option

The value of an option (also known as price or premium) is comprised of two components: Intrinsic Value and Time Value. The intrinsic value of an option is the gain to the holder on immediate exercise of the option. It is therefore the amount by which the option is in-the-money. An out of the money option and an at the money option has no intrinsic value at all.

In other words, Intrinsic Value of a call option is -

IV = $(S_T - X)$ when $S_T > X$; and

= 0 Otherwise

Similarly, for a put option, the intrinsic value is given by -

IV = $(X - S_T)$ when $S_T < X$; and

= 0 Otherwise

For example, the intrinsic value of a call option on Infosys shares with an exercise price of ₹1,380 and spot price of ₹1,350 would be ₹30. However, the concept of intrinsic value is real only in case of an American option. In case of a European option, this concept is only notional.

Time value is the amount by which the price of an option exceeds its intrinsic value. Also referred to as extrinsic value, time value decays over time. In other words, the time value of an option is directly related to how much time an option has until expiration. The more time an option has until expiration, the greater is the possibility that the option will become in-the-money. That is, an out of the money option can move into-the-money or one already in-the-money option can become more so. Consequently, the time value of an option is always positive for an out of the money option and is usually positive for an in the money option. Moreover, the more time that remains until an option expires, the higher the time value tends to be. However, at expiration an option would have only intrinsic value and no time value.

For an exchange traded option, therefore, the price (or premium) that is paid to buy the same is equal to the sum of intrinsic value and time value. For in-the-money option the time value is option price less the intrinsic value while for at-the-money and out-of-the money option, the price is equal to the time value only as intrinsic value is zero for such an option.

For example, suppose, the July, 2022 call option on Infosys shares having an exercise price of ₹1,380 is currently trading at ₹20. Now, if the current spot price for Infosys shares is ₹1,390, the intrinsic value of the option will be = 1,390 – 1,380 = ₹10 and time value will be = 20 – 10 = ₹10. In this situation, the option is already in-the-money. However, if the current spot price is ₹1,350, the option will be out-of-the-money and in that case the intrinsic value will be zero. Thus, the price of ₹20 will represent only time value.

When an investor purchases an OTM or ATM option, whose premium is equal to its time value, there is a greater risk that the option will be worthless at its expiration date, since it is already out of or at the money, but the time to expiration also presents the opportunity that it will become in the money. This is why, it is important to understand the time value as a part of an option's premium. Due to the greater risk of the option having no value, OTM and ATM options have lower premiums than ITM options on the same underlying asset. However, this greater risk also comes with greater reward as OTM and ATM have larger percent gains in profit than ITM options.

⊙ Maximum and Minimum Value of Options

Since an American option can be exercised prior to the expiration date, the maximum and minimum values are as follows:

Maximum and Minimum Value of American Options

Particulars	Maximum Value	Minimum Value
American Call	$C_{Max} = S_T$	$C_{Min} = Max\ (0, S_T – X.\ e^{-rt})$
American Put	$P_{Max} = X$	$P_{Min} = Max\ (0, X – S_T)$

Since, a European option can be exercised only at expiration, the maximum and minimum values are as follows:

Maximum and Minimum Value of European Options

Particulars	Maximum Value	Minimum Value
European Call	$C_{Max} = S_T$	$C_{Min} = Max\ (0, S_T – X.\ e^{-rt})$
European Put	$P_{Max} = X.\ e^{-rt}$	$P_{Min} = Max\ (0, X.\ e^{-rt} – S_T)$

Consider the following illustration.

Illustration 29

A stock is selling at ₹500. If the risk-free rate of interest is 10% p.a. continuously compounded, then calculate the minimum and maximum value of the following option contract.

a. A European call option with strike price of ₹ 450 maturing in 1 month, 2 month and 3 month.

b. A European put option with strike price of ₹ 450 maturing in 1 month, 2 month and 3 month.

Solution:

a. Calculation of C_{Min} = Max (0, S_T – X. e^{-rt}) for European Call

Strike Price (X) (₹)	Time (t)	C_{Min} = Max (0, S_T – X. e^{-rt}) (₹)
450	1	Max (0, 500 – 450 × $e^{-0.10 \times 1/12}$) = Max (0, 53.77) = 53.77
500	2	Max (0, 500 – 500 × $e^{-0.10 \times 2/12}$) = Max (0, 8.26) = 8.26
550	3	Max (0, 500 – 550 × $e^{-0.10 \times 3/12}$) = Max (0, –36.42) = 0

b. Calculation of C_{Min} = Max (0, S_T – X. e^{-rt}) for European Put

Strike Price (X) (₹)	Time (t)	P_{Min} = Max (0, X. e^{-rt} – S_T) (₹)
450	1	Max (0, 450 × $e^{-0.10 \times 1/12 - 500}$) = Max (0, – 53.77) = 0
500	2	Max (0, 500 × $e^{-0.10 \times 2/12 - 500}$) = Max (0, – 8.26) = 0
550	3	Max (0, 550 × $e^{-0.10 \times 3/12 - 500}$) = Max (0, 36.42) = 36.42

⊙ Determinants of Option Premium

The factors on which the level of premium depends are —

(a) Exercise price: Exercise Price or Strike Price refers to the price at which the contract is agreed upon. When buying an Option, an investor can choose from a set of Strike Prices, for which Options can be bought/sold. Based on Strike Price chosen, the Option Premium will vary as follows —

Exercise Price	Call Option Premium is —	Put Option Premium is —
High	LOW	HIGH
	As the Exercise Price goes up, the value of the Option i.e., (S_T − X) goes down. Therefore, it becomes less valuable and its price i.e., premium declines	As the Exercise Price goes up, the value of the Option i.e., (X−S_T) goes up. Therefore, it becomes more valuable and its price or premium increases.
Low	HIGH	LOW
	As the Exercise Price goes down, the value of the Option i.e., (S_T − X) goes up. Therefore, it becomes more valuable and its price or premium increases.	As the Exercise Price goes up, the value of the Option i.e., (X − S_T) goes down. Therefore, it becomes less valuable and its price i.e., premium declines

(b) Current Price of the Underlying Asset: Other things remaining constant, if the current market price of the asset goes up, value of the call option increases (since the possibility of exercising the call also increases) and put option decreases. If the current market price decreases, value of put option increases (as the possibility of exercising the put option also increases), and value of call option decreases.

(c) Maturity or Expiry Date: Longer the time to maturity, higher the period of uncertainty, and hence higher the option premium. Therefore, an option with 3 months to maturity will have a higher premium than an option with 1 month to maturity.

(d) Volatility of stock prices: Volatility of stock price in the spot market (Cash Market) also contributes to premium. Higher volatility would mean prices hitting the extremes, and the buyer of option would exercise his option, which would result in a higher obligation on the part of the seller of the option. Therefore, the values of both calls and puts increase as volatility increases. Greater the volatility, higher will be the premium, and vice-versa.

(e) Interest Rate Movement: As interest rates increases, the expected return required by the investors on the stock also increases. Therefore, the present value of the future returns decreases. If the interest rate decreases, the expectations also go down.

(f) Market Factors:

(i) Liquidity in the market i.e., extent of money available for investment.

(ii) Dividend expectations i.e., if a large dividend is expected from a stock, the call option will be priced less, since dividend when declared and distributed, the prices will fall down. When cash market prices fall, the value of a call option also goes down.

13.3.2 Option Strategies

Options can be used as an effective hedging tool for risk management and also for speculative motive. Various options strategies which are used for these purposes are discussed below.

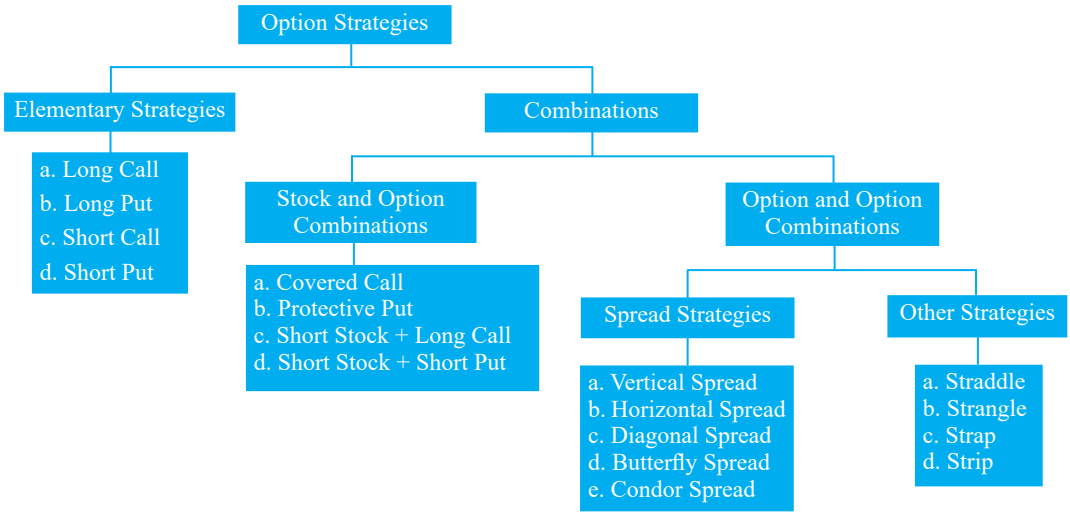


Figure 13.7: Option Strategies- at a Glance

I. Elementary Strategies

There are four elementary strategies associated with options. They are –

a. Long Call i.e., buying a call option

b. Long Put i.e., buying a put option

c. Short Call i.e., writing a call option

d. Short Put i.e., writing a put option

These have already been discussed in this Module.

In case of Short Call, if the writer of the call option does not own the underlying asset, it is called Uncovered Call or Naked Call option. In this case, if the price of the underlying asset rises, the call writer has no protection, and would be required to buy the asset in the open market and deliver the same to the option holder. Accordingly, his loss will be unlimited.

Similarly, in case of short put, if the writer of the put option does not sell the underlying asset in the Cash Market (either his own asset or borrowed asset), it is called Uncovered Put or Naked Put option. If the price of the underlying asset falls, the put writer will not have any protection but to buy the stock at a very high price. Accordingly, his loss will be unlimited.

II. Combinations

A. Stock and Option Combinations

Options are useful hedging instruments and may be used efficiently to protect loss. For example, when an investor holds a long position in stock (i.e., already had bought stock), he may resort to option contracts. Similarly, when he has a short position in stock and apprehends a price rise, he may also resort to option contracts.

There are two popular strategies in this context.

a. Covered Call

Strategy	Long Stock + Short Call
Apprehension or Expectation	Decline in stock price/ gain from small price increase.
Mechanism	As price declines, loss on stock increases but option gets OTM. So, the gain on writing option i.e., premium helps to recover the loss on stock. In case of small price rise up to strike price, option remains OTM and hence premium received is the gain, but for large price increase, option becomes ITM and loss on option consumes the gain on stock.
When Effective	Small decline or small rise in price.

Consider the following illustration.

Illustration 30

Mr. B has bought shares of XYZ Ltd. @ ₹3,850 per share. In order to protect himself from possible price decline he has written a call option with strike price of ₹4,000 for 3 months at a premium of ₹80. He expects that the price rise, if at all, won't be beyond ₹4,000. Show his expiration day payoff within a range of ₹3,500 to ₹4,500.

Solution:

Expiration day pay-off of Mr. B

Spot Price (S_T) ₹	Pay-off on Stock (₹)	Status of Short Call (₹)	Pay-off on Short Call (₹)	Total Pay-off (₹)
(1)	(2)	(3)	(4)	(5) = (2) +(4)
3,500	(–)350	OTM	+ 80	(–) 270
3,600	(–)250	OTM	+ 80	(–) 170
3,700	(–)150	OTM	+ 80	(–) 70
3,740	(–)110	OTM	+ 80	(–) 30
3,770	(–)80	OTM	+ 80	Nil
3,800	(–)50	OTM	+ 80	+ 30
3,900	+ 50	OTM	+ 80	+ 130
4,000	+ 150	ATM	+ 80	+ 230
4,200	+ 350	ITM	(–) 120	+ 230
4,500	+ 650	ITM	(–) 420	+ 230

Note: Pay-off on short call includes premium received.

It can be seen that small price fall up to ₹3,770 is protected while small price increases up to ₹4,000 has given additional income. However, large price increase opportunities could not be realized as the gain was capped to ₹230 only.

b. Protective Put

Strategy	Long Stock + Long Put
Apprehension or Expectation	Decline in stock price/ participate in the bull run.
Mechanism	As price declines, loss on stock increases but option becomes profitable. So, profit on put option offsets the loss on stock.
When Effective	Moderate to sharp decline in stock price.

Consider the following illustration.

Illustration 31

Mr. C has bought shares of P Ltd. @ ₹310 per share. In order to protect himself from possible price decline he has bought a put option with strike price of ₹270 per share for 3 months at a premium of ₹2 per share. He expects that the price will fall sharply. Show his expiration day pay-off within a price range of ₹240 to ₹340.

Solution:

Expiration day pay-off of Mr. C

Spot Price (S_T) ₹	Pay-off on Stock (₹)	Status of Long Put (₹)	Pay-off on Long Put (₹)	Total Pay-off (₹)
(1)	(2)	(3)	(4)	(5) = (2) +(4)
240	(–) 70	ITM	+ 28	(–) 42
260	(–) 50	ITM	+ 8	(–) 42
270	(–) 40	ATM	(–) 2	(–) 42
280	(–) 30	OTM	(–) 2	(–) 32
300	(–) 10	OTM	(–) 2	(–) 12
320	+ 10	OTM	(–) 2	+ 8
340	+ 30	OTM	(–) 2	+ 28

Note: Pay-off on long put is after deduction of premium paid.

His loss is restricted to ₹42. Moreover, as price starts rising beyond ₹310 (i.e., the purchase price), it starts earning profit.

c. Short Position in Stock with Long Call

Strategy	Short Stock + Long Call
Apprehension	Increase in stock price.
Mechanism	As price rises, loss on short stock is covered by profit on long call.
When Effective	Large price appreciation.

Consider the following illustration.

Illustration 32

Mr. C sells short the shares of Q Ltd. at ₹300 per share. In order to hedge the loss against possible price increase, he buys a call option with a strike price of ₹350 per share. He pays a premium of ₹5 per share. Show his expiration day pay-off within a price range of ₹280 to ₹380.

Solution:

Expiration day pay-off of Mr. C

Spot Price (S_T) ₹	Pay-off on Stock (₹)	Status of Long Call (₹)	Pay-off on Long Call (₹)	Total Pay-off (₹)
(1)	(2)	(3)	(4)	(5) = (2) +(4)
280	+ 20	OTM	(–) 5	+ 15
290	+ 10	OTM	(–) 5	+ 5
300	0	OTM	(–) 5	(–) 5
320	(–) 20	OTM	(–) 5	(–) 25
340	(–) 40	OTM	(–) 5	(–) 45
350	(–) 50	ATM	(–) 5	(–) 55
360	(–) 60	ITM	+ 5	(–) 55
380	(–) 80	ITM	+ 25	(–) 55

Note: Pay-off on long call is after deduction of premium paid.

It can be seen that his loss is limited in case of large price appreciation.

d. Short Position in Stock with Short Put

Strategy	Short Stock + Short Put
Apprehension	Increase in stock price.
Mechanism	As price rises, loss on short stock is covered by profit on short put.
When Effective	Small price decline.

Consider the following illustration.

Illustration 33

Mr. D sells short the shares of R Ltd. at ₹300 per share. As he expects a small price decline, he writes a put option with a strike price of ₹270 per share. He pays a premium of ₹5 per share. Show his expiration day pay-off within a price range of ₹250 to ₹330.

Solution:

Expiration day pay-off of Mr. D

Spot Price (S_T) ₹	Pay-off on Stock (₹)	Status of Short Put (₹)	Pay-off on Short Put (₹)	Total Pay-off (₹)
(1)	(2)	(3)	(4)	(5) = (2) +(4)
250	+ 50	ITM	(–) 15	+ 35
260	+ 40	ITM	(–) 5	+ 35
270	+ 30	ATM	+ 5	+ 35
280	+ 20	OTM	+ 5	+ 25
290	+ 10	OTM	+ 5	+ 15

300	0	OTM	+ 5	+ 5
310	(–) 10	OTM	+ 5	(–) 5
330	(–) 30	OTM	+ 5	(–) 25

Note: Pay-off on short call includes premium received.

It can be seen that he makes additional gain for small price fall up to ₹270, thereafter his gain is limited for further price decline.

B. Combination of Options

Spread Strategies

In options trading, an option spread is created by the simultaneous purchase and sale of options of the same class on the same underlying security but with different strike prices and/or expiration dates. Any spread that is constructed using calls can be referred to as a call spread. Similarly, put spreads are spreads created using put options.

Option buyers can consider using spreads to reduce the net cost of entering a trade. Naked option sellers can use spreads instead to lower margin requirements so as to free up buying power while simultaneously putting a cap on the maximum loss potential.

The three basic classes of spreads are the vertical spread, the horizontal spread and the diagonal spread. They are categorized by the relationships between the strike price and expiration dates of the options involved.

Vertical spreads are constructed using options of the same class, same underlying security, same expiration month, but at different strike prices.

Horizontal or calendar spreads are constructed using options of the same underlying security, same strike prices but with different expiration dates.

Diagonal spreads are created using options of the same underlying security but different strike prices and expiration dates.

a. Vertical Spread

(i) Bull Spread

With Call Options (Bull Call Spread)

Strategy	Buy a Call with a lower strike (ITM) + Sell a Call with a higher strike (OTM).
Risk	Limited to any initial premium paid in establishing the position. Maximum loss occurs where the underlying falls to the level of the lower strike or below.
Reward	Limited to the difference between the two strikes minus net premium cost. Maximum profit occurs where the underlying rises to the level of the higher strike or above.
When Effective	Investor is moderately bullish.
BEP	Strike Price of Purchased call + Net Debit Paid

Consider the following illustration.

Illustration 34

Mr. PQR buys a Nifty Call with a Strike price ₹ 4,100 at a premium of ₹ 172.45 and he sells a Nifty Call option with a strike price ₹4,400 at a premium of ₹37.40. The net debit here is ₹135.05 which is also his maximum loss. Show his pay-off profile on expiration within a price range of ₹3,800 to ₹4,500

Solution:

Expiration day pay-off of Mr. PQR

Spot Price (S_T) ₹	Pay-off on Long Call (₹)	Pay-off on Short Call (₹)	Net Pay-off (₹)
(1)	(2)	(3)	(4) = (2) + (3)
3,800	(–) 172.45	37.40	(–) 135.05
3,900	(–) 172.45	37.40	(–) 135.05
4,000	(–) 172.45	37.40	(–) 135.05
4,100	(–) 172.45	37.40	(–) 135.05
4,200	(–) 72.45	37.40	(–) 35.05
4,235.05	(–) 37.40	37.40	0
4,300	27.55	37.40	64.95
4,400	127.55	37.40	164.95
4,500	227.55	-62.60	164.95

The strategy has produced limited gain in a moderately bullish market.

- **With Put Options (Bull Put Spread)**

Strategy	Sell a Put with a higher strike (OTM) + Buy a Put with a lower strike (Further OTM).
Risk	Limited. Maximum loss occurs where the underlying falls to the level of the lower strike or below.
Reward	Limited to the net premium credit. Maximum profit occurs where underlying rises to the level of the higher strike or above.
When Effective	When the investor is moderately bullish.
BEP	Strike Price of Short Put – Net Premium Received

Consider the following illustration.

Illustration 35

Mr. XYZ sells an ABC Ltd. Put option with a strike price of ₹4,000 at a premium of ₹21.45 and buys a further OTM ABC Ltd. Put option with a strike price ₹3,800 at a premium of ₹3.00 when the current market price of ABC Ltd. shares is at ₹4,191.10, with both options expiring on 31st July.

Show his pay-off profile on expiration within a price range of ₹3,500 to ₹4,200

Solution:

Expiration day pay-off of Mr. XYZ

Spot Price (S_T) ₹	Pay-off on Long Put (₹)	Pay-off on Short Put (₹)	Net Pay-off (₹)
(1)	(2)	(3)	(4) = (2) + (3)
3,500	297	(–) 478.55	(–) 181.55
3,600	197	(–) 378.55	(–) 181.55
3,700	97	(–) 278.55	(–) 181.55
3,800	(-) 3	(–) 178.55	(–) 181.55
3,900	(-) 3	(–) 178.55	(–) 181.55

3,981.55	(-) 3	3	0
4,000	(-) 3	21.45	18.45
4,100	(-) 3	21.45	18.45
4,200	(-) 3	21.45	18.45

Note: Net premium received = 21.45 – 3 = ₹18.45

The strategy earns a net income for the investor as well as limits the downside risk of a Put sold.

(ii) Bear Spread

With Call Options (Bear Call Spread)

The Bear Call Spread strategy can be adopted when the investor feels that the stock / index is either range bound or falling. The concept is to protect the downside of a Call Sold by buying a Call of a higher strike price to insure the Call sold.

Strategy	Sell a Call with a lower strike (ITM) + Buy a Call with a higher strike (OTM).
Risk	Limited to the difference between the two strikes minus the net premium.
Reward	Limited to the net premium received for the position i.e., premium received for the short call minus the premium paid for the long call.
When Effective	When the investor is mildly bearish on market.
BEP	Lower Strike + Net credit

Consider the following Illustration

Illustration 36

Mr. ABC is bearish on Reliance. He sells an ITM call option with strike price of ₹ 2,600 at a premium of ₹154 and buys an OTM call option with strike price ₹2,800 at a premium of ₹49. Show his pay-off profile on expiration within a price range of ₹2,400 to ₹3,200.

Solution:

Expiration day pay-off of Mr. ABC

Spot Price (S_T) ₹	Pay-off on Short Call (₹)	Pay-off on Long Call (₹)	Net Pay-off (₹)
(1)	(2)	(3)	(4) = (2) + (3)
2,400	154	(–) 49	105
2,500	154	(–) 49	105
2,600	154	(–) 49	105
2,700	54	(–) 49	5
2,705	49	(–) 49	0
2,800	(–) 46	(–) 49	(–) 95
2,900	(–) 146	51	(–) 95
3,000	(–) 246	151	(–) 95
3,100	(–) 346	251	(–) 95
3,200	(–) 446	351	(–) 95

The strategy earns a net income for the investor as well as limits the downside risk of a Call sold.

- **With Put Options (Bear Put Spread)**

This strategy requires the investor to buy an in-the-money (higher) put option and sell an out-of-the-money (lower) put option on the same stock with the same expiration date.

Strategy	BUY A PUT with a higher strike (ITM) + SELL A PUT with a lower strike (OTM).
Risk	Limited to the net amount paid for the spread. i.e., the premium paid for long position less premium received for short position.
Reward	Limited to the difference between the two strike prices minus the net premium paid for the position.
When Effective	When you are moderately bearish on market direction.

Consider the following illustration.

Illustration 37

Nifty Bank is presently at 2694. Mr. ABC expects Nifty Bank to fall. He buys one Nifty Bank ITM Put with a strike price ₹2,800 at a premium of ₹132 and sells one Nifty Bank OTM Put with strike price ₹2,600 at a premium ₹52. Show his pay-off profile on expiration within a price range of ₹2,400 to ₹3,000.

Solution:

Expiration day pay-off of Mr. ABC

Spot Price (S_T) ₹	Pay-off on Long Put (₹)	Pay-off on Short Put (₹)	Net Pay-off (₹)
(1)	(2)	(3)	(4) = (2) + (3)
2,400	268	(–) 148	120
2,500	168	(–) 48	120
2,600	68	52	120
2,700	(–) 32	52	20
2,800	(–)132	52	(-) 80
2,900	(–) 132	52	(-) 80
3,000	(–) 132	52	(-) 80

The strategy also has limited gains and is therefore ideal when markets are moderately bearish.

(iii) Box Spread

The box spread, or long box, is a common arbitrage strategy that involves buying a bull call spread together with the corresponding bear put spread, with both vertical spreads having the same strike prices and expiration dates.

The long box is used when the spreads are underpriced in relation to their expiration values.

Box spread Construction

Buy	1	ITM	Call
Sell	1	OTM	Call
Buy	1	ITM	Put
Sell	1	OTM	Put

Essentially, the arbitrageur is simply buying and selling equivalent spreads and as long as the price paid for the box is significantly below the combined expiration value of the spreads, a riskless profit can be locked in immediately.

Expiration Value of Box = Higher Strike Price – Lower Strike Price

Risk-free Profit = Expiration Value of Box – Net Premium Paid

Consider the following example.

Example

Suppose XYZ stock is trading at ₹45 in June and the following prices are available:

- JUL 40 put – ₹1.50
- JUL 50 put – ₹6
- JUL 40 call – ₹6
- JUL 50 call – ₹1

Buying the bull call spread involves purchasing the JUL 40 call for ₹600 and selling the JUL 50 call for ₹100. The bull call spread costs: ₹600 – ₹100 = ₹500

Buying the bear put spread involves purchasing the JUL 50 put for ₹600 and selling the JUL 40 put for ₹150. The bear put spread costs: ₹600 – ₹150 = ₹450

The total cost of the box spread is: ₹500 + ₹450 = ₹950

The expiration value of the box is computed to be: (₹50 – ₹40) × 100 = ₹1,000.

Since the total cost of the box spread is less than its expiration value, a risk-free arbitrage is possible with the long box strategy. It can be observed that the expiration value of the box spread is indeed the difference between the strike prices of the options involved.

If XYZ remain unchanged at ₹45, then the JUL 40 put and the JUL 50 call expire worthless while both the JUL 40 call and the JUL 50 put expires in-the-money with ₹500 intrinsic value each. So, the total value of the box at expiration is: ₹500 + ₹500 = ₹1000.

Suppose, on expiration in July, XYZ stock rallies to ₹50, then only the JUL 40 call expires in-the-money with ₹1,000 in intrinsic value. So, the box is still worth ₹1,000 at expiration.

What happens when XYZ stock plummets to ₹40? A similar situation happens but this time it is the JUL 50 put that expires in-the-money with ₹1,000 in intrinsic value while all the other options expire worthless. Still, the box is worth ₹1,000.

As the trader had paid only ₹950 for the entire box, his profit comes to ₹50.

b. Horizontal/Time Spread and Calendar Spread

Calendar spread consists of opposing positions in two options of the same kind (call or put) where both have same strike price but different time to expire.

A common example of a calendar spread is to sell a call option with shorter maturity and buy a call option with longer maturity but both at the same exercise price. The longer the maturity, the more expensive is the option. Hence, a calendar spread requires an initial investment.

c. Diagonal Spread

A diagonal spread can be created by using similar options with different strike prices and also different time to expire.

For example, one can create a diagonal spread by using a call with lower exercise price with longer maturity and selling a call with higher exercise price with shorter maturity.

d. Butterfly Spread

Butterfly Spread is an option strategy which combines a Bull Spread and Bear Spread and involves three different strike prices.

Butterfly spread is taken up if investors are of the view that the underlying security is not highly volatile and there is not going to be a substantial rise or fall in its prices.

A butterfly spread involves positioning in options with three different strike prices (X_1, X_2, and X_3) where X_2 is the halfway between X_1 and X_3.

There are two possible butterfly spread strategies as follows:

(i) Long Call Butterfly

Strategy	Sell 2 ATM Call, buy 1 ITM Call Option and buy 1 OTM Call Option
Risk	Net debit paid.
Reward	Difference between adjacent strikes minus net debit.
When Effective	When the investor is neutral on market direction and bearish on volatility.
Upper BEP	Strike Price of Higher Strike Long Call - Net Premium Paid
Lower BEP	Strike Price of Lower Strike Long Call + Net Premium Paid

Consider the following illustration.

Illustration 38

Nifty is at 9200. Mr. P expects very little movement in Nifty. He sells 2 ATM Nifty Call Options with a strike price of ₹9,200 at a premium of ₹97.90 each, buys 1 ITM Nifty Call Option with a strike price of ₹9,100 at a premium of ₹141.55 and buys 1 OTM Nifty Call Option with a strike price of ₹9,300 at a premium of ₹64. The Net debit is ₹9.75. Show his pay-off profile on expiration within a price range of ₹8,900 to ₹9,600.

Solution:

Expiration day pay-off of Mr. P

Spot Price (S_T) ₹	Payoff from 2 ATM Calls Sold (₹)	Payoff from 1 ITM Call purchased (₹)	Payoff from 1 OTM Call purchased (₹)	Total Pay-off (₹)
(1)	(2)	(3)	(4)	(5) = (2) + (3) +(4)
8,900	195.80	(−) 141.55	(−) 64	(−) 9.75
9,000	195.80	(−) 141.55	(−) 64	(−) 9.75
9,100	195.80	(−) 141.55	(−) 64	(−) 9.75
9,109.75	195.80	(−) 131.80	(−) 64	0
9,200	195.80	(−) 41.55	(−) 64	90.25

9,290.25	15.30	48.70	(–) 64	0
9,300	(–) 4.20	58.45	(–) 64	(–) 9.75
9,400	(–) 204.20	158.45	36	(–) 9.75
9,500	(–) 604.20	258.45	136	(–) 209.75
9,600	(–) 804.20	358.45	236	(–) 209.75

(ii) Short Call Butterfly

Strategy	Buy 2 ATM Call, sell 1 ITM Call Option and sell 1 OTM Call Option
Risk	Limited to the net difference between the adjacent strikes (₹100 in this example) less the premium received for the position.
Reward	Limited to the net premium received for the option spread.
When Effective	When the investor is neutral on market direction and bullish on volatility. Neutral means that you expect the market to move in either direction - i.e., bullish and bearish.
Upper BEP	Strike Price of Highest Strike Short Call − Net Premium Received
Lower BEP	Strike Price of Lowest Strike Short Call + Net Premium Received

Consider the following illustration.

Illustration 39

Nifty is at 9200. Mr. P expects large volatility in the Nifty irrespective of which direction the movement is, upwards or downwards. Mr. XYZ buys 2 ATM Nifty Call Options with a strike price of ₹9,200 at a premium of ₹97.90 each, sells 1 ITM Nifty Call Option with a strike price of ₹9,100 at a premium of ₹141.55 and sells 1 OTM Nifty Call Option with a strike price of ₹9,300 at a premium of ₹64. The Net Credit is ₹9.75. Show his pay-off profile on expiration within a price range of ₹8,900 to ₹9,600.

Solution:

Expiration day pay-off of Mr. P

Spot Price (S_T) ₹	Payoff from 2 ATM Calls Purchased (₹)	Payoff from 1 ITM Call Sold (₹)	Payoff from 1 OTM Call Sold (₹)	Total Pay-off (₹)
(1)	(2)	(3)	(4)	(5) = (2) + (3) +(4)
8,900	(–) 195.80	141.55	64	9.75
9,000	(–) 195.80	141.55	64	9.75
9,100	(–) 195.80	141.55	64	9.75
9,109.75	(–) 195.80	131.80	64	0
9,200	(–) 195.80	41.55	64	(–) 90.25
9,290.25	(–) 15.30	(–) 48.70	64	0
9,300	4.20	(–) 58.45	64	9.75
9,400	204.20	(–) 158.45	(–) 36	9.75
9,500	604.20	(–) 258.45	(–) 136	209.75
9,600	804.20	(–) 358.45	(–) 236	209.75

e. Condor

A condor spread is a non-directional options strategy that limits both gains and losses while seeking to profit from either low or high volatility. There are two types of condor spreads. A long condor seeks to profit from low volatility and little to no movement in the underlying asset. A short condor seeks to profit from high volatility and a sizable move in the underlying asset in either direction.

III. Other Strategies

a. Straddle

One of the least sophisticated option strategies that can accomplish a market neutral objective with a lot less hassle is known as a straddle. A straddle involves a call and a put option with the same exercise price and same expiration date. There are two types of straddles as follows:

(i) Long Straddle: The long straddle is designed around the purchase of a put and a call at the exact same strike price and expiration date. The long straddle is meant to take advantage of the market price change by exploiting increased volatility. The strategy is helpful when the investor expects a large movement in stock price but does not know in which director the price will move.

Strategy	Buy Put + Buy Call with same strike price and expiration date
Risk	Limited to the initial premium paid.
Reward	Unlimited
When Effective	When the investor thinks that the underlying stock / index will experience significant volatility in the near term.
Upper BEP	Strike Price of Long Call + Net Premium Paid
Lower BEP	Strike Price of Long Put − Net Premium Paid

(ii) Short Straddle: The short straddle is designed around the sale of a put and a call at the exact same strike price and expiration date. This strategy works well when market is in a sideway pattern.

Strategy	Sell Put + Sell Call with same strike price and expiration date
Risk	Unlimited
Reward	Limited to the premium received.
When Effective	When the investor thinks that the underlying stock / index will experience very little volatility in the near term.
Upper BEP	Strike Price of Short Call + Net Premium Received
Lower BEP	Strike Price of Short Put − Net Premium Received

b. Strangle

A Strangle is a slight modification to the Straddle to make it cheaper to execute. This strategy involves the simultaneous buying of a slightly out-of-the-money (OTM) put and a slightly out-of-the-money (OTM) call of the same underlying stock / index and expiration date. For a Strangle to make money, it would require greater movement on the upside or downside for the stock / index than it would for a Straddle. Strangles can also be of two types.

(i) Long Strangle

Strategy	Buy OTM Put + Buy OTM Call
Risk	Limited to the premium received
Reward	Unlimited
When Effective	When the investor thinks that the underlying stock / index will experience very high levels of volatility in the near term.
Upper BEP	Strike Price of Long Call + Net Premium Paid
Lower BEP	Strike Price of Long Put − Net Premium Paid

(ii) Short Strangle

Strategy	Sell OTM Put + Sell OTM Call
Risk	Unlimited
Reward	Limited to the premium received
When Effective	This options trading strategy is taken when the options investor thinks that the underlying stock will experience little volatility in the near term.
Upper BEP	Strike Price of Short Call + Net Premium Received
Lower BEP	Strike Price of Short Put − Net Premium Received

c. Strap

Strap Strategy is similar to Long Straddle, the only difference is the quantity traded. A trader will buy two Call Options and one Put Options.

d. Strip

Strip Strategy is the opposite of Strap Strategy. When a trader is bearish on the market and bullish on volatility then he will implement this strategy by buying two ATM Put Options and one ATM Call Option, of the same strike price, expiry date and underlying asset.

13.3.3 Put-Call Parity Relationship, Valuation of Options using Binomial Tree Approach and Black-Scholes Model, The Greeks

⊙ **Put-Call Parity Relationship**

Put-call parity shows the relationship that has to exist between European put and call options that have the same underlying asset, expiration, and strike prices. The concept says that the price or value of the European call option with a certain strike price and expiration date can be derived from the value of a European put option with same strike price and expiration date and vice-versa. The relationship is based on a 'no arbitrage' assumption.

As per Put-Call Parity, $C + PV(X) = P + S_T$.

Where, C is the call price (or premium), P is the put price (or premium), S_T is the spot price and PV(X) = the present value of the strike price (X).

Here, $PV(X) = X. e^{-rt}$ where, r = risk free rate of interest continuously compounded and t = time to expiration.

Therefore, $C + X. e^{-rt} = P + S_T$

Or, $C = P + S_T - X. e^{-rt}$

Or, $P = C + X. e^{-rt} - S_T$

The concept is, however, not applicable in case of American option.

Consider the following illustration.

Illustration 40

A stock is currently trading at ₹500. A call option with 3 months to maturity at an exercise price of ₹550 is available on the stock at a premium of ₹12. What should be the price of the put option on the same stock with same strike price and expiration? The risk-free rate of interest is 8% p.a. continuously compounded.

Solution:

Given, C = ₹12; K = ₹550, r = 8% p.a. and t = 3 months = 3/12 year

Using the Put-Call Parity Relationship,

$P = C + X.\ e^{-rt} - S_T = 12 + 550 \times e^{-0.08 \times 3/12} - 500$

Or, P = 12 + 539.11 – 500

Or, P = 51.11

So, the price of the put option will be ₹51.11.

⊙ Option Valuation/Pricing Models

The term option valuation is used to convey two meanings:

(i) The value of the option at the time of its maturity. It is the amount that the option buyer receives from the option writer on exercising the option

(ii) The value of the option at the time of its writing. This is also referred to as option premium or option price. The three major methods of option valuation are as follows:

A. Binomial Method

B. Black-Scholes Model

These are discussed below.

A. Binomial Model of Option Pricing

This model assumes that the underlying asset can have only two values at the time of maturity of an option. One will be higher than the strike price and the other will be lower than the strike price.

The option premium calculated under this method provides risk-free rate of return, at either of the two prices, on the investment made by option writer. (In case the option writer uses borrowed funds, the return at risk free rate will be provided on borrowed funds.)

Following are the factors considered in valuing / pricing an option under the Binomial Tree Approach —

(a) Current Spot Price of the underlying asset (S_T or SP_0);

(b) Exercise Price under the Options Contract (X or EP);

(c) Set of Expected Future Spot Prices - one above the Exercise Price and one below the Exercise Price (FP_1 and FP_2 respectively);

(d) Risk Free Rate of Return (r);

(e) Period to Expiry (t).

This model requires construction of a tree to include alternative possibilities of upward and downward movement and to evaluate each node for the possible values. Binomial model can again be single stage model or multi-stage model. The general steps of Binomial Model are –

(a) Construct a binomial tree.

(b) Calculate implied volatility

(c) Calculate expected pay-off

(d) Discount the expected pay-off

Here, implied volatility is the probability of asset prices going upwards. It is calculated by the formula $p = \frac{f-d}{u-d}$

Where, u = 1 + % increase in stock price or FP_1/SP_0;

and, d = 1 + % increase in stock price or FP_2/SP_0

So, Probability of asset prices going downwards. It is calculated by the formula = $1 - p = \frac{u-f}{u-d}$

Now, expected pay-off from a call option = $C_u \times p + C_d \times (1-p) = C_u [\frac{f-d}{u-d}] + C_d [\frac{u-f}{u-d}]$

Value of a call option = Present value of expected pay-off

Value of a call Option = $\frac{C_u [\frac{f-d}{u-d}] + C_d [\frac{u-f}{u-d}]}{f}$

where, f = future value factor = e^{rt} (for continuously compounded risk-free rate of return).

Similarly, value of a put option = $\frac{P_u [\frac{f-d}{u-d}] + P_d [\frac{u-f}{u-d}]}{f}$

Consider the following illustrations.

Illustration 41 (Single Stage Model)

A stock is currently trading at ₹50. It can either go up or down by 20% in a period of 3 months. If the risk-free rate of return is 8% p.a. continuously compounded, calculate the value of call and put option with strike price of ₹50 and maturity of 3 months using Single Stage Binomial Option Pricing Model.

Solution:

		Spot Price (SP_0)	Exercise Price (EP)	Long Call Pay-off	Long Put Pay-off
	+20%	60	50	$C_u = 10$	$P_u = 0$
50					
	-20%	40	50	$C_d = 0$	$P_d = 10$

Here, u = 1 + 20% = 1.20 and d = 1 – 20% = 0.80 and $f = e^{rt} = e^{0.08 \times 3/12} = 1.02$

Then, $p = \frac{f-d}{u-d} = \frac{1.02-0.80}{1.2-0.8} = 0.55$ and 1– p = 0.45

So, value of call Option = $\frac{C_u [\frac{f-d}{u-d}] + C_d [\frac{u-f}{u-d}]}{f} = \frac{10 \times 0.55 + 0 \times 0.45}{1.02} = ₹5.39$

Value of a put option = $\frac{P_u [\frac{f-d}{u-d}] + P_d [\frac{u-f}{u-d}]}{f} = \frac{0 \times 0.55 + 10 \times 0.45}{1.02} = ₹4.41$

Illustration 42 (Two Stage Model)

A stock is currently trading at ₹50. It can either go up or down by 20% in a period of 6 months. If the risk-free rate of return is 8% p.a. continuously compounded, calculate the value of call and put option with strike price of ₹45 and maturity of 3 months using Two Stage Binomial Option Pricing Model.

Solution:

		Spot Price (SP_0)		Spot Price (SP_0)	Exercise Price (EP)	Long Call Pay-off	Long Put Pay-off
			+ 20%	72	45	27	0
	+ 20%	60					
50			-20%	48	45	3	0
			+20%				
	(-) 20%	40			45	0	13
			-20%	32			

Here, u = 1 + 20% = 1.20 and d = 1 – 20% = 0.80 and $f = e^{rt} = e^{0.08 \times 3/12} = 1.02$

$$p = \frac{f - d}{u - d} = \frac{1.02 - 0.80}{1.2 - 0.8} = 0.55 \text{ and } 1-p = 0.45$$

$$\text{Value of Call (at Node 60)} = \frac{27 \times 0.55 + 3 \times 0.45}{1.02} = 15.89$$

$$\text{Value of Call (at Node 40)} = \frac{3 \times 0.55 + 0 \times 0.45}{1.02} = 1.62$$

However, at Node 40, the option is OTM and hence not exercised. So, its value = 0.

$$\text{Value of Call (at Node 50)} = \frac{15.89 \times 0.55 + 0 \times 0.45}{1.02} = 8.57$$

Similarly,

Value of Put (at Node 60) = 0 (as OTM)

$$\text{Value of Put (at Node 40)} = \frac{0 \times 0.55 + 13 \times 0.45}{1.02} = 5.73$$

$$\text{Value of Put (at Node 50)} = \frac{0 \times 0.55 + 5.73 \times 0.45}{1.02} = 2.52$$

B. Black-Scholes Option Pricing Model

Fisher Black and Myron Scholes provided the first ever closed form of solution for pricing the European calls in 1973 and published the path-breaking paper titled "The pricing of options and corporate liabilities" in Journal of Political Economy. Prof. Scholes and Prof. Merton were awarded the Nobel Prize for their contributions in option pricing.

The pricing intuition involves constructing a replicating hedge portfolio comprising a long position in stock and a short position in a zero-coupon bond. The hedge portfolio will be constituted in such a way that at any given point of time its value will always be equal to the option's price at that time. If the option's price differs from the hedge portfolio's value, then arbitrageurs' actions will bring back the equilibrium relationship. The proportion of stocks and bonds will be determined by the Black-Scholes formula.

The model is based on the following assumptions:

a. The underlying asset does not pay any dividend.

b. The market is efficient.

c. There is no transaction costs or taxes.

d. Risk free rate of interest is constant during the life of the option and it is known.

e. Stock returns are log-normally distributed.

f. European exercise terms are used.

As per the model, the value of call option is given by –

$C = S. N(d_1) – X. e^{-rt}. N(d_2)$

$P = X. e^{-rt}. N(-d_2) – S. N(-d_1)$

Where, $d_1 = \frac{Ln(\frac{s}{x}) + (r+\frac{\sigma^2}{2})\times t}{\sigma\sqrt{t}}$ and $d_2 = d_1 – \sigma.\sqrt{t}$

N = Cumulative normal distribution function

Ln = Natural logarithm,

S = Spot price of the stock,

X = Exercise price of the option,

r = Annual risk-free rate of return,

t = Time to expiry of the option, and

σ = Annual volatility of the stock.

Consider the following illustration.

Illustration 43

The current price of a stock is ₹90 per share. The risk-free interest rate is 8% (annualized, continuous compounding). If the volatility of the stock is 23% p.a., what is the price of the ₹80 call option expiring in 6 months?

Solution:

S = Spot price of the stock = ₹90

X = Exercise price of the option = ₹80

r = Annual risk-free rate of return = 8% p.a.

t = Time to expiry of the option = 6 months = 6/12 years = 0.5 years

σ = Annual volatility of the stock = 23%

Now, $d_1 = \frac{n(\frac{s}{x}) + (r+\frac{\sigma^2}{2})\times t}{\sigma\sqrt{t}} = d_1 = \frac{Ln(\frac{90}{80}) + (0.08 + \frac{0.23^2}{2}) \times 0.5}{0.23\sqrt{0.5}} = \frac{0.1178 + 0.1064 \times 0.5}{0.1626} = 1.0517$

$d_2 = d_1 – \sigma\times\sqrt{t} = 1.0517 – 0.23\times\sqrt{0.5} = 0.8891$

N (1.0517) = 0.8535 and N (0.8891) = 0.8130

$C = S. N(d_1) – X. e^{-rt}. N(d_2)$

$= 90 \times 0.8535 – 80 \times e^{-0.08 \times 0.5} \times 0.8130$ = ₹14.33

$P = X. e^{-rt.} N(-d_2) – S. N(-d_1)$

$= 80 \times e^{-0.08 \times 0.5} \times (1 – 0.8130) – 90 \times (1 – 0.8535)$ = ₹1.19

The Greeks

In options trading, you may notice the use of certain Greek alphabets when describing risks associated with various positions. They are known as "the Greeks" and we shall discuss the four most commonly used ones. They are delta, gamma, theta and vega.

a. Delta:

Delta of a Stock Option is the ratio of the change in the price of the stock option to the change in the price of the underlying stock. It measures the sensitivity of Options Price to the movement in the prices of the underlying asset.

Deltas of Call Option and put Option:

(a) Delta of a Call Option is always positive.

(b) Delta of a Put Option is always negative.

Formula:

$$\text{Delta } (\Delta) = \frac{\text{Change in Option Price i.e., Option Premium}}{\text{Change in Stock Price}} = \frac{\text{CI. Option Price} - \text{Op. Option Price}}{\text{CI. Stock Price} - \text{Op. Stock Price}}$$

Example: On 01.12.2024, when the trade opens, the stock price of Amitech Castings is ₹240. It rises to ₹250. The December 2024 Call Option on Amitech Castings started at ₹20. It moved to ₹23.

Delta of Call Options of Amitech Castings is computed as under —

$$\text{Delta } (\Delta) = \frac{\text{CI. Option Price} - \text{Op. Option Price}}{\text{CI. Stock Price} - \text{Op. Stock Price}} = \frac{23 - 20}{250 - 240} = 0.30$$

Application: Value of Delta is the number of units of the underlying stock which an investor should hold for each option sold in order to create a riskless hedge.

Delta Hedging: Creating a Riskless Hedge using Options and Underlying Stock, is called Delta Hedging.

Rebalancing: Since Delta changes, the investor's position remains delta hedged (or delta neutral) for only a relatively short period. The hedge should be adjusted periodically. This is called re-balancing.

Delta Values:

Option position is	Value of Delta
In the Money [Extreme beneficial CMP]	Almost Equal to ± 1 [Never beyond than ± 1]
At the Money	Approximately equal to ± 0.50
Out of Money [Extreme beneficial CMP]	Near to Zero.

b. Gamma:

The gamma of an option is defined as the rate of change of the option's delta with respect to the price of the underlying, when all else remains the same. It's the second partial derivative of the option price with respect to the underlying price. In other words, gamma is the rate at which delta will change. The delta captures the extent of change and the gamma measures the pace of the change. It is also called as Curvature.

Gamma is also called as the Second Derivative of an Option Premium since it measures the sensitivity of Delta, which is the first measure of sensitivity of Option's Price to Market Price of the Underlying Asset.

Evaluation based on Gamma Values:

(a) If Gamma is small, delta changes slowly, and re-balancing act (i.e., adjustments to keep a portfolio delta neutral) needs not be done on a frequent basis.

(b) If Gamma value is high, delta is highly sensitive to the price of the underlying asset. This situation requires the re-balancing to be done on a frequent basis.

c. Vega or Lambda:

Vega of the option measures the sensitivity of option price with respect to the volatility of the price of the underlying asset. It considers both movement in price and also decrease in period to expiry of an option. It is calculated as change in the option premium for a unit change in the volatility of the price of the underlying asset. For both call and put options, Vega lies between zero and infinity. Vega is maximum for at the money options with long term to expiration. High Vega reflects the higher chances of an option going "In-the-money" at any point in time during the currency of the contract. So, options with high Vega are attractive to the option buyer Vega is positive for Option Buyer and negative for Option Seller.

d. Theta:

Theta measures the sensitivity of the option's price with respect to its time to expiry i.e. Time Value of an Option. It measures the change of the price of the option with the passage of time. It is also referred to as the time decay of the stock or portfolio. Theta Values for both the Call and the Put Option lies between Zero and the Total Value of the Option. It will be positive or negative based on the nature of the investor (holder or writer). Value of Theta is generally measured on per day basis, and therefore, value of Theta would vary for every trading day, based on the movement in Stock Prices. When Option Contract approaches the expiry date, option tends to become less valuable. Since the Stock Price and the option price move in tandem, the value of theta remains same or uniform towards the end of the options contract.

e. Rho

Rho is the last and the least used Greek. Rho helps us to understand the change in option premium, which are not linked to the underlying stock movement. For instance, interest rates changes may cause a change in option premium.

Rho indicates the change in option value for a one percentage change in the interest rate.

Example: A Rho of 1.50 indicates the option's theoretical value will increase by 1.50 if the interest rate is decreased by 1%.

An increase in interest rates increases the value of calls and decreases the value of puts. A decrease in interest rates decreases the value of calls and increases the value of puts. The range of the Rho Value also depends on the position that a person holds in the Option. Long calls and short puts have positive Rho. Short calls and long puts have negative Rho.

Illustration 44

Kiran, who trades in shares in the spot market, follows the rule "When prices are rising - Buy; When prices are falling –sell". She ensures that her portfolio is intact at the end of every three months, even if she buys or sells in between.

She is a first timer to the options market and wishes to apply the above rule in the options market, where she understands that buy equates to call option and sell equals put option. For a three-month horizon, the following information is available for 5 securities (of which Kiran holds sufficient quantities):-

Scrip	Spot Price (₹)	Outlook	Exercise Price (₹)
Greaves Cotton Ltd	345	Increase by 15%	400
NDTV	395	Increase by 10%	430
Punj Loyd	260	Decrease by 5%	250
ITC Ltd	160	Increase by 5%	170
TCS Ltd	1120	Decrease by 10%	1000

If the expectations translates into actual, and Kiran follows her spot market rule in options market as well, how much she would have earned in the options market? You may assume that she will deal only in 100 units of scrip at a time and exercises her option, come what may.

What would have been the position if she had opted for potions, not based on spot market rules, but based on option market rules i.e. Exercise Price > Expected Price = Put Option; Expected Price > Exercise Price = Call Option?

What is the lesson to be learnt? Ignore transaction costs, time value of money and cost of options.

Solution:

1. Choice of Option – Spot Market Rules

(a) Choice of Option and Expected Price

Scrip	Expectation for the next 3 Months	Option Chosen	Spot Price (₹)	Expected Price after 3 Months (₹)
Greaves	Increase by 15%	Call	345	345 +15% = 397
NDTV	Increase by 10%	Call	395	395 + 10% = 434
Punj Loyd	Decrease by 5%	Put	260	260 – 5% = 247
ITC Ltd	Increase by 5%	Call	160	160 + 5% = 168
TCS Ltd	Decrease by 10%	Put	1,120	1,120 – 10% = 1,008

(b) Gain / Loss Statement on Options Contracts

Scrip	3- Month' Spot Price (₹)	Strike Price (₹)	Option Chosen	Action	No. of Scripts	Gain/Loss [Sale Value less Buy cost] (₹)
Greaves	397	400	Call	Buy under option at Strike Price. Sell spot at Spot Price.	100	Loss (300) [100 × (397 – 400)]
NDTV	434	430	Call	Buy under option at Strike Price. Sell spot at Spot Price.	100	Gain 400 [100 × (434 – 430)]
Punj Loyd	247	250	Put	By spot at Spot Price. Sell under option at Strike Price.	100	Gain 300 [100 × (250 – 247)]
ITC Ltd	168	170	Call	Buy under option at Strike Price. Sell spot at Spot Price.	100	Loss (200) [100 × (168 – 170)]
TCS Ltd	1,008	1,000	Put	By spot at Spot Price. Sell under option at Strike Price	100	Loss (800) [100 × (1000 – 1008)]
						Total = Loss (600)

Note: If Kiran had chosen not to exercise the option for loss inflicting scrips, she would have earned ₹1,300.

2. Choice of Option – Option Market Rules

(a) Choice of Option and Expected Price

Scrip	Spot Price (₹)	Expectation for the next 3 Months	Expected Price after 3 Months [EP] (₹)	Strike Price [SP] (₹)	EPvs.SP [Higher]	Option Chosen
Greaves	345	Increase by 15%	345 + 15% = 397	400	SP	Put
NDTV	395	Increase by 10%	395 + 10% = 434	430	EP	Call
Punj Loyd	260	Decrease by 5%	260–5% = 247	250	SP	Put
ITC Ltd	160	Increase by 5%	160 + 5% = 168	170	SP	Put
TCS Ltd	1,120	Decrease by 10%	1,120–10% = 1,008	1,000	EP	Call

(b) Gain / Loss statement on Options Contracts

Scrip	3-Months' Spot Price (₹)	Strike Price (₹)	Option Chosen	Action	No. of Scrips	Gain / Loss [Sale Value Less Buy Cost] (₹)
Greaves	397	400	Put	By spot at Spot Price. Sell under option at Strike Price.	100	300 [100 × (400–397)]
NDTV	434	430	Call	By under option at Strike Price. Sell spot at Spot Price	100	400 [100 × (434–430)]
Punj Loyd	247	250	Put	By spot at Spot Price. Sell under option at Strike Price.	100	300 [100 × (250–247)]
ITC Ltd	168	170	Put	By spot at Spot Price. Sell under option at Strike Price.	100	200 [100 × (170–168)]
TCS Ltd	1,008	1,000	Call	Buy under option at Strike Price. Sell spot at Spot Price.	100	800 [100 × (1008–1000)]
						Total = Gain 2,000

Inference:

(a) In the cash market, movement in the prices is relevant. In the options market, the expected price on the date of expiry and the strike price are relevant.

(b) Gain or loss under options is based on the Exercise Price and the spot price on the date of expiry and not on the basis of direction of movement in strike price.

(c) In a rising market, buying a Call Option may still not yield return if the expected spot price is less than the exercise price. Call options and put options can be bought both under a bearish market as well as a bullish market.

Illustration 45

Sundar Ramalingam had entered into 5 Put Options and 5 Call Options in different securities, the particulars of which are given below, along with their exercise price and actual market price on the date of exercise-

Call Options		
Security	Exercise Price (₹)	Actual Market Price (₹)
P	370	376
Q	450	444
R	1790	1700
S	135	140
T	953	953

Put Options		
Security	Exercise Price (₹)	Actual Market Price (₹)
A	118	122
B	758	758
C	350	340
D	65	69
E	230	220

What is his position on the date of exercise and what would he do?

Solution:

1. Put Options [Right to Sell]

Security	Exercise Price (EP) (₹)	Actual Market Price (AMP) (₹)	AMP vs. EP [Higher]	Position	Action
A	118	122	AMP	Out of Money	Lapse
B	758	758	Equal	At the Money	No Action
C	350	340	EP	In the Money	Exercise
D	65	69	AMP	Out of Money	Lapse
E	230	220	EP	In the Money	Exercise

2. Call Option [Right to Buy]

Security	Exercise Price (EP)(₹)	Actual Market Price (AMP) (₹)	AMP vs. EP [Higher]	Position	Action
P	370	376	AMP	In the Money	Exercise
Q	450	444	EP	Out of Money	Lapse
R	1790	1700	EP	Out of Money	Lapse
S	135	140	AMP	In the Money	Exercise
T	953	953	Equal	At the Money	No Action

Illustration 46

Given the following:

	Amount (₹)
Strike price	200
Current stock price	185
Risk free rate of interest	5% p.a

(a) Calculate the theoretical minimum price of a European put option after 6 months.

(b) If European put option price is ₹5, then how can an arbitrageur make profit.

Solution:

1. Computation of Theoretical Minimum Price

Particulars	Value
Exercise price	₹200
Current Stock Price	₹185
Risk Free Rate of Return (r)	5% or 0.05
Time (in years)	6 ÷ 12 = 0.5
Theoretical Minimum Price	= Present Value of Exercise Price − Current Stock Price = 200 × e^{-rt} − 185 = 200 ÷ $e^{0.05\times0.5}$ − 185 = (200 ÷ 1.02532) − 185 = 195.0611 − 185 = 10.0611

Inference: Since the Value of Put Option is more than the price of the Put Option, it is under priced and the recommended action will be to Buy the Put Option.

2. Cash Flows to make Profit for the Arbitrageur Activity Flow:

(i) Arbitrageur can borrow the amount required to buy the Put Option and Stock at the rate of 5% p.a. for 6 months.

(ii) Buy Put Option.

(iii) Take the opposite position and buy stock at spot price.

(iv) At the end of six months, exercise the Put option and realise the receipts.

(v) Pay the amount of Borrowing together with Interest.

Particulars	Time	₹
1. Borrow at the rate of 5% for 6 months [185+5]	T_o	190
2. Buy Put Option	T_o	(5)
3. Buy Stock at Spot Price	T_o	(185)
4. Exercise the Put Option and realise the Sale Proceeds	T_1	200
5. Repay the amount of Borrowing together with Interest [190 × $e^{0.05\times0.5}$] = [190 × 1.02532]	T_1	194.81
6. Net Gain made [(4) – (5)]	T_1	5.19

Note: The amount of gain is the minimum amount and will Increase with every Increase in Spot

Price as on the Exercise Date.

Illustration 47

Stock of Swarup Air Cargo Ltd is currently quoted at ₹112. Ascertain the Time Value and Intrinsic Value of Option from the following particulars available in relation to derivatives market-

Put Options		
Situation	Exercise Price	Premium (₹)
A	98	10
B	103	11
C	109	11
D	112	11
E	116	12
F	120	12
G	124	13
H	128	13

Call Options		
Situation	Exercise Price	Premium (₹)
A	125	9
B	122	10
C	119	10
D	115	11
E	112	11
F	109	11
G	106	12
H	103	12

Solution:

1. Put Options [Right to Sell]

Situation	Exercise Price (EP) (₹)	Current Market Price (CMP) (₹)	Premium (₹)	Intrinsic Value [Maximum of (EP-CMP), 0] (₹)	Time Value [Maximum of (Premium - Intrinsic Value), 0] (₹)
(1)	(2)	(3)	(4)	(5) = Max [(2) − (3), 0]	(6) =Max [(4) − (5), 0]
A	98	112	10	0	10
B	103	112	11	0	11
C	109	112	11	0	11
D	112	112	11	0	11
E	116	112	12	4	8
F	120	112	12	8	4
G	124	112	13	12	1
H	128	112	13	16	0

2. Call Options [Right to Buy]

Situation	Exercise Price (EP) (₹)	Current Market Price (CMP) (₹)	Premium	Intrinsic Value [Maximum of (CMP-EP), O] (₹)	Time Value [Maximum of (Premium- Intrinsic Value), 0] (₹)
(1)	(2)	(3)	(4)	(5) = Max [(3)–(2), 0]	(6) =Max [(4)–(5), 0]
A	125	112	9	0	9
B	122	112	10	0	10
C	119	112	10	0	10
D	115	112	11	0	11
E	112	112	11	0	11
F	109	112	11	3	8
G	106	112	12	6	6
H	103	112	12	9	3

Illustration 48

Determine the value of option, both call and put, on expiry for the stock of Nirmal Spice Foods (NSF) Ltd. from the following information-

- Exercise Price – ₹510
- Spot Price on Exercise Date Ranges between ₹495 and ₹525, with interval of ₹5.

Also state what will be the action on the above range of prices for both the options.

Solution:

1. Call Option (Right to Buy)

Situation	Exercise Price (EP) (₹)	Spot Price on Expiry Date (SP_E) (₹)	Value of Call [Maximum of (SP_E - EP), 0] (₹)	Action
(1)	(2)	(3)	(4) =Max [(3)– (2), 0]	(5)
A	510	495	495 – 510 = – 15 → 0	Lapse
B	510	500	500 – 510 = – 10 → 0	Lapse
C	510	505	505 – 510 = – 5 → 0	Lapse
D	510	510	510 – 510 = 0 → 0	Lapse
E	510	515	515 – 510 = 5 → 5	Exercise
F	510	520	520 – 510 = 10 → 10	Exercise
G	510	525	525 – 510 = 15 → 15	Exercise

2. Put Option (Right to Sell)

Situation	Exercise Price (EP) (₹)	Spot Price on Expiry Date (SPE) (₹)	Value of Put [Maximum of (EP - SPE -), 0] (₹)	Action
(1)	(2)	(3)	(4) =Max [(2)– (3), 0]	(5)
A	510	495	510 – 495 = 15 → 15	Exercise
B	510	500	510 – 500 = 10 → 10	Exercise
C	510	505	510 – 505 = 5 → 5	Exercise
D	510	510	510 – 510 = 0 → 0	Lapse
E	510	515	510 – 515 = –5 → 0	Lapse
F	510	520	510 – 520 = –10 → 0	Lapse
G	510	525	510 – 520 = –15 → 0	Lapse

Illustration 49

CMC Ltd. shares are presently quoted at 100. 3-Month's call option carries a premium of ₹15 for a strike price of ₹120, and 3-Month's put option carries a premium of ₹20 for a strike price of ₹120.

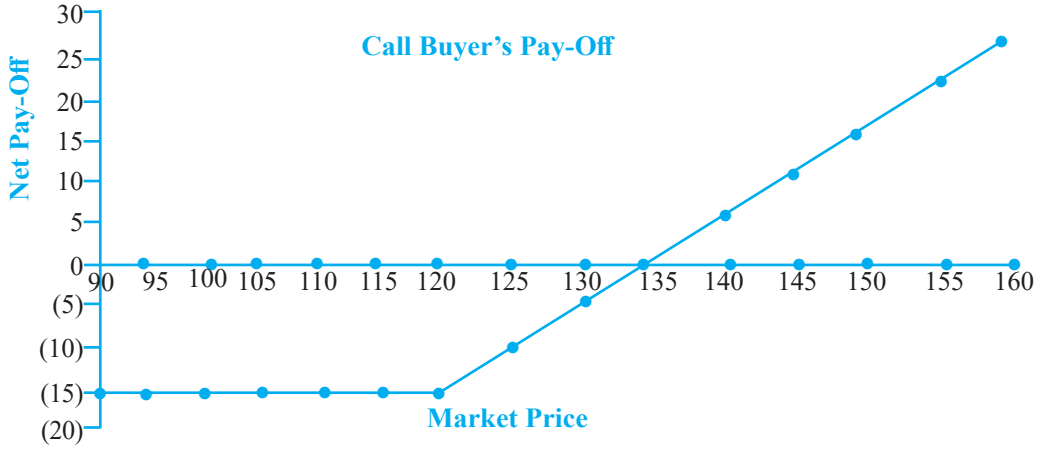
If the spot price on the expiry date is in the range of ₹90 to ₹160, with intervals of ₹5, prepare Net Pay-Off Graph for both Call Option and Put Option, from both the buyer's perspective and the option writer's perspective.

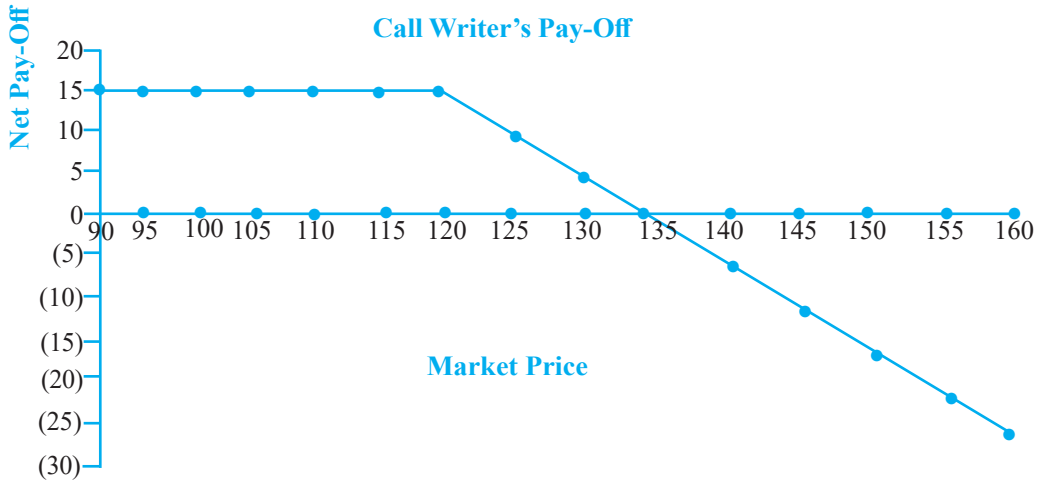
Solution:

1. Net Pay-Off [Call Option] = Buyer and Writer of Call Option

Spot Price on Expiry Date (SP_E) ₹	Exercise Price (EP) (₹)	Value of Call [Gross Profit] [Maximum of (SP_E - EP), 0] (₹)	Action (₹)	Option Premium (₹)	Net Pay-Off [Call Holder] (₹)	Net Pay-Off [Call Writer] (₹)
(1)	(2)	(3) = Max[(1)–(2),0]	(4)	(5)	(6) = (3)–(5)	(7) = (5)–(3)
90	120	90 – 120 = – 30 → 0	Lapse	15	0–15 = (15)	15–0=15
95	120	95 – 120 = – 25 → 0	Lapse	15	0–15 = (15)	15–0=15
100	120	100 – 120 = – 20 → 0	Lapse	15	0–15 = (15)	15–0=15
105	120	105 – 120 = – 15 → 0	Lapse	15	0–15 = (15)	15–0=15
110	120	110 – 120 = – 10 → 0	Lapse	15	0–15 = (15)	15–0=15
115	120	115 –120 = – 5 → 0	Lapse	15	0–15 = (15)	15–0=15
120	120	120 – 120 = 0 → 0	Lapse	15	0–15 = (15)	15–0=15
125	120	125 – 120 = 5 → 5	Exercise	15	5–15= (10)	15–5=10
130	120	130 – 120 = 10 → 10	Exercise	15	10–15=(5)	15–10= 5
135	120	135 – 120 = 15 → 15	Exercise	15	15–15=0	15–15=0
140	120	140 – 120 = 20 → 20	Exercise	15	20–15=5	15–20 = (5)
145	120	145 – 120 = 25 → 25	Exercise	15	25–15=10	15–25 = (10)
150	120	150 – 120 = 30 → 30	Exercise	15	30–15=15	15–30=(15)
155	120	155 – 120 = 35 → 35	Exercise	15	35–15=20	15–35 = (20)
160	120	160 – 120 = 40 → 40	Exercise	15	40–15=25	15–40 = (25)

2. Pay-Off Graph [Call Option]

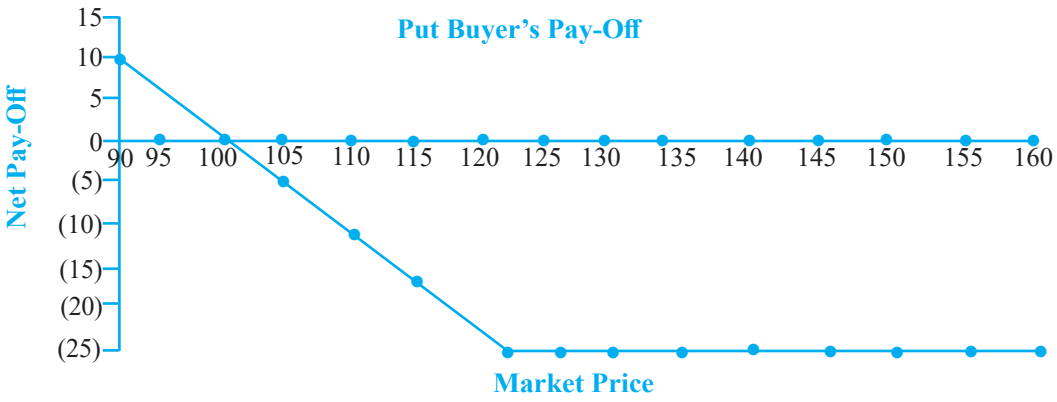




3. Net Pay-Off [Put Option] = Buyer and Writer of Put Option

Spot Price on Expiry Date (SP_E) (₹)	Exercise Price (EP) (₹)	Value of Put [Gross Profit] [Maximum of ($EP-SP_E$), 0]	Action (₹)	Option Premium (₹)	Net Pay-Off [Call Holder] (₹)	Net Pay-Off [Call Writer] (₹)
(1)	(2)	(3) = Max [(2) − (1),0]	(4)	(5)	(6)=(3) − (5)	(7) =(5) − (3)
90	120	120−90 = 30 → 30	Exercise	20	30− 20= 10	20−30 = (10)
95	120	120−95 = 25 → 25	Exercise	20	25−20= 5	20−25 = (5)
100	120	120−100=20 → 20	Exercise	20	20−20= 0	20−20 = 0
105	120	120−105 = 15 → 15	Exercise	20	15−20 = (5)	20−15 = 5
110	120	120−110= 10 → 10	Exercise	20	10−20 = (10)	20−10 = 10
115	120	120−115 = 5 → 5	Exercise	20	5−20 = (15)	20−5 = 15
120	120	120−120 = 0 → 0	Lapse	20	0−20 = (20)	20−0 = 20
125	120	120−125 = −5 → 0	Lapse	20	0−20 = (20)	20−0 = 20
130	120	120−130 = −10 → 0	Lapse	20	0−20 = (20)	20−0 = 20
135	120	120−135 = −15 → 0	Lapse	20	0−20 = (20)	20−0 = 20
140	120	120− 140 = −20 → 0	Lapse	20	0−20 = (20)	20−0 = 20
145	120	120−145 = −25 → 0	Lapse	20	0−20 = (20)	20−0 = 20
150	120	120−150 = − 30 → 0	Lapse	20	0−20 = (20)	20−0 = 20
155	120	120−155 = −35 → 0	Lapse	20	0−20 = (20)	20−0 = 20
160	120	120−160 = −40 → 0	Lapse	20	0−20 = (20)	20−0 = 20

4. Pay-off Graph [Put Option]



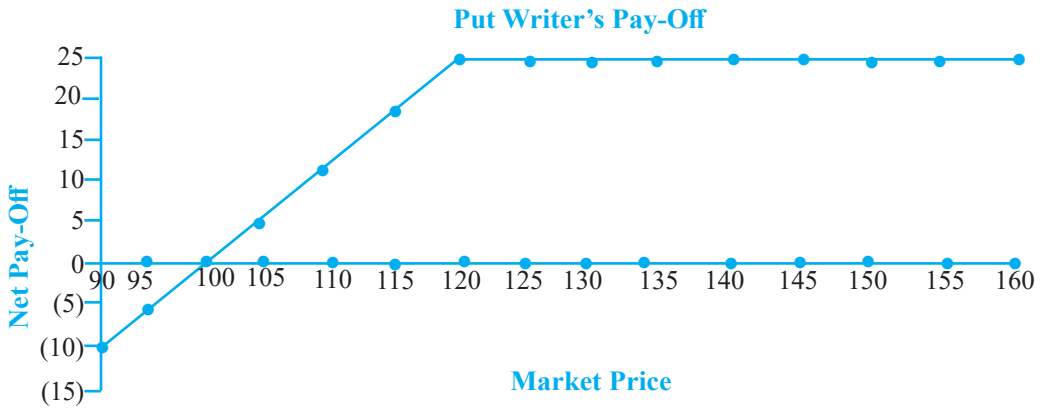


Illustration 50

Fill up the blanks in the following "Break Even Price" table –

Case	Option	Party	Exercise Price (₹)	Premium (₹)	Market Price (₹)
1	Call	Buyer	?	20	160
2	?	Seller	2000	300	1700
3	?	Buyer	50	10	40
4	?	Seller	80	10	90
5	Put	Buyer	?	50	250
6	?	Seller	320	50	370
7	Call	Buyer	680	100	?
8	Call	Seller	?	80	580
9	Put	Buyer	1200	?	1020
10	Put	Seller	?	330	1870

Solution:

Case	Option	Party	Exercise Price (EP) (₹)	Premium (₹)	Market Price (₹)	Reason I Computation (₹)
1	Call	Buyer	140	20	160	Call →MP = EP + Premium, for Pay Off to be "0". → 160 – 20 = 140
2	Put	Seller	2000	300	1700	2000 – 300 = 1700 → MP = EP – Premium. Therefore, it is a Put Option
3	Put	Buyer	50	10	40	50 – 10 = 40 → MP = EP – Premium. Therefore, it is a Put Option
4	Call	Seller	80	10	90	80 + 10 = 90 → MP = EP + Premium. Therefore, it is a Call Option
5	Put	Buyer	300	50	250	Put Option → MP = EP – Premium. → EP = MP + Premium = 250 + 50 = 300
6	Call	Seller	320	50	370	320 + 50 = 370 → MP = EP + Premium. Therefore, it is a Call Option
7	Call	Buyer	680	100	780	Call →MP = EP + Premium, for Pay Off to be "0". 680 + 100 = 780
8	Call	Seller	500	80	580	Call →MP = EP + Premium, for Pay Off to be "0". → EP – Premium → 580 – 80 = 500.
9	Put	Buyer	1200	180	1020	Put →MP = EP – Premium, for Pay Off to be "0". → Premium = EP – MP → 1200 – 1020 = 180
10	Put	Seller	2200	330	1870	Put →MP = EP − Premium, for Pay Off to be "0". → EP = MP + Premium → 1870 + 330 = 2,200.

Illustration 51

Fill up the blanks in the following table ---

Case	Option	Exercise Price (EP) (₹)	Premium (₹)	Holder's Maximum Loss (₹)	Holder's Maximum Gain (₹)	Writer's Maximum Loss (₹)	Writer's Maximum Gain	Break Even Price (₹)
1	Call	520	75	?	?	?	?	?
2	Put	700	140	?	?	?	?	?
3	Put	?	?	4	16	16	4	?
4	Call	?	?	200	?	Unlimited	?	1725
5	?	350	70	70	280	280	70	280
6	?	80	?	12	Unlimited	?	12	?
7	?	?	?	?	?	Unlimited	18	138
8	?	?	?	?	?	592	148	592
9	Call	240	40	40	Unlimited	Unlimited	40	280
10	Put	900	?	180	?	?	?	?

Solution:

Case	Option	Exercise Price (EP) (₹)	Premium (₹)	Holder's Maximum Loss (₹)	Holder's Maximum Gain (₹)	Writer's Maximum Loss (₹)	Writer's Maximum Gain (₹)	Break Even Price (₹)
1	Call	520	75	75	Unlimited	Unlimited	75	595
2	Put	700	140	140	560	560	140	560
3	Put	20	4	4	16	16	4	16
4	Call	1525	200	200	Unlimited	Unlimited	200	1725
5	Put	350	70	70	280	280	70	280
6	Call	80	12	12	Unlimited	Unlimited	12	92
7	Call	120	18	18	Unlimited	Unlimited	18	138
8	Put	740	148	148	592	592	148	592
9	Call	240	40	40	Unlimited	Unlimited	40	280
10	Put	900	180	180	720	720	180	720

General Rules:

1. All Cases, Option Holder's Maximum Loss = Option Writer's Maximum Gain = Amount of Premium
2. If Option Type = Call, then-
   - Holder's Maximum Gain = Writer's Maximum Loss = Unlimited [Conversely, if Holder's Maximum Gain = Writer's Maximum Loss = Unlimited, then the nature of the option is Call]
   - Break Even Price (No Profit No Loss Situation) = Exercise Price Plus Premium
3. If Option Type = Put, then -
   - Holder's Maximum Gain = Writer's Maximum Loss = Exercise Price Less Premium = Break Even Price [Conversely, if Holder's Maximum Gain = Writer's Maximum Loss = Break Even Price, then nature of the option is Put]
   - Break Even Price (No Profit No Loss Situation) = Exercise Price Less Premium

Illustration 52

A put and a call option each have an expiration date 6 months hence and an exercise price ₹9.

The interest rate for the 6 month period is 3 percent.

(a) If the put has a market price of ₹2 and share is worth ₹10 per share, what is the value of the call?

(b) If the put has a market price of ₹2 and the call ₹4. what is the value of the share per share?

(c) If the call has a market value of ₹5 and market price of the share is ₹12 per share what is the value of the put?

Solution:

Under Put Call Parity -

→ Value of Call + Present Value of Exercise Price = Current Spot Price + Value of Put

→ $C + EP \times e^{-rt} = SP_0 + P$

Case (a)	Case (b)	Case (c)
→ $C + EP \times e^{-rt} = SP_0 + P$	→ $C + EP \times e^{-rt} = SP_0 + P$	→ $C + EP \times e^{-rt} = SP_0 + P$
→ $C = SP_0 + P - EP \times e^{-rt}$	→ $SP_0 = C + EP \times e^{-rt} - P$	→ $P = C + EP \times e^{-rt} - SP_0$
→ $C = 10+2 - (9 \times e^{-0.03 \times (6/12)})$	→ $SP_0 = 4 + (9 \times e^{-0.03 \times (6/12)}) - 1$	→ $P = 5 + 9 \times e^{-0.03 \times (6/12)} - 12$
→ C = 12 – (9 ÷ 1.01511)	→ $SP_0 = 4 + (9 \div 1.01511) - 1$	→ P = 5 + 8.86 – 12
→ C = 12 – 8.86 = 3.14	→ SP_0 = 11.86	→ P = 1.86
Value of Call = ₹3.14	Value of Share = ₹11.86	Value of Put = ₹1.86

Illustration 53

Shoaib is furnished with the following information about securities of two Companies- Manju Ltd. and Sanju Ltd.

1. **Manju Ltd:** Call option is traded at ₹85 for an exercise price of ₹700. Presently stock of Manju Ltd is traded for ₹650. Put option is available for ₹110.
2. **Sanju Ltd:** Put option is traded at ₹40 at an exercise price of ₹200. Presently stock of Sanju are traded at ₹180. Call options are available for ₹20.

If Shoaib has sufficient money and also holds stock in both these companies, wants to make only ascertained profit and no loss, advise him on the course of action and resultant gain/loss.

Risk Free Interest rate may be assumed at 10% and expiry date for option is 3 Months away.

Solution:

1. Manju Ltd

(a) Computation of Theoretical Value of Put Option:

C+ PV of EP of Call = CMP+P

→ ₹85 + ₹700 × $e^{-0.10 \times 0.25}$ = ₹650 + P

→ P = ₹85 + ₹700 ÷ 1.025 – ₹650

→ P = ₹85 + ₹682.73- ₹650

= ₹117.73

(b) Evaluation: Theoretical Price of ₹117.73 > Actual Price of ₹110. Therefore, Put Option is undervalued.

(c) Action:

Now	3-Months Later
⅄ Sell Call Option (Write Call) at ₹ 85. ⅄ Borrow ₹675 at 10% p.a. for 3 months (Cost of Buying put at ₹110 + Cost of Stock in Spot Market ₹650- Inflow for writing Call ₹85) ⅄ Buy Put option at ₹110 ⅄ Buy Stock at ₹650	**Spot Price on Expiry is more than ₹700** ⅄ **Inflow:** Call Option will be exercised by the Option Holder. Therefore, sell stock and receive for ₹700. ⅄ **Outflow:** Repay borrowal of ₹692 including interest i.e. ₹675 × $e^{0.10 \times 0.25}$ = ₹675 × 1.0253 ⅄ **Net Gain 3-Months Later:** ₹700 – ₹ 692 =₹8 **Spot Price on Expiry is less than ₹700** ⅄ **Inflow:** Exercise put Option. Sell stock and receive ₹700 ⅄ **Outflow:** Repay borrowal of ₹692 including interest i.e ₹675 × $e^{0.10 \times 0.25}$ = ₹675 × 1.0253 ⅄ **Net Gain 3-Months Later:** ₹700 – ₹692 = ₹8

2. Sanju Ltd.

(a) Computation of Theoretical Value of Call Option:

C+ PV of EP of Call= CMP + P

→ C+ ₹200 × $e^{-0.10\times0.25}$= ₹180 + 40

→ C = ₹220 – ₹200 ÷ 1.0253

→ C= ₹220 – ₹195= ₹25

(b) Evaluation: Theoretical Price of ₹25 > Actual Price of ₹20. Therefore, Call Option is undervalued.

(c) Action:

Now	3-Months later
▲ Sell Put Option (Write Put) at ₹40. (Inflow) ▲ Sell Stock at ₹180 ▲ Buy Call Option at ₹20 ▲ Invest ₹200 in Risk free Investments at 10% p.a. for 3 Months(Receipt on sale of stock ₹180 + Receipt on sale of put Option ₹40 – Cost of Call Option ₹20)	**Spot Price on Expiry is more than ₹200** ▲ **Inflow:** Realize ₹205 from Investment including interest (₹200 × $e^{0.10\times0.25}$ = ₹200 ×1.0253) ▲ **Outflow:** Call option will be exercised. Pay ₹200 and buy stock. ▲ **Net Gain 3-Months later:** ₹205 – ₹200 = ₹5 ▲ **Spot price on Expiry is less than ₹200** ▲ **Inflow:** Realize ₹205 from Investment including interest (₹200 × $e^{0.10\times0.25}$ = ₹200 × 1.0253) ▲ **Outflow:** Put Option holder will exercise option. Pay ₹200 and buy stock. ▲ **Net Gain 3-Months Later:** ₹ 205 – ₹200 = ₹5

Illustration 54

On 19th July Following are the spot rates – Spot USD/ EUR 1.20000 and INR/ USD 44.8000

Following are the quotes of European Options:

Currency Pair	Call/Put	Strike Price	Premium	Expiry Date
USD/EUR	Call	1.2000	$0.035	Oct. 19
USD/EUR	Put	1.2000	$0.04	Oct. 19
INR/USD	Call	44.8000	Rs. 0.12	Dec. 19
INR/USD	Put	44.8000	Rs. 0.04	Dec. 19

(a) A Trader sells an At- The-Money Spot Straddle expiring at three Months (Oct. 19). Calculate the gain or loss if three months later the spot rate is USD/EUR 1.2900.

(b) Which strategy gives a profit to the dealer if five months later (Dec.19) expected spot rate is INR/USD 45.00. Also calculate profit for a transaction of USD 1.40 Millions.

Solution:

1. Straddle Strategy- At the Money – Profit or Loss Calculation

Straddle is an Option Strategy which involves buying/ writing a call and put with the same strike price and same expiry date. A trader sells a Straddle, will be selling a call option & a put option with strike price of USD 1.2000 per EUR.

2. Computation of Net Pay - Off

Particulars	Amount
Exercise Price	$1.2000
Spot Price as on Exercise Date	$1.2900
Action of the Buyer of the Option	Call – Exercise Put - Lapse
Loss on Call Option to the Writer = Strike Price – Exercise Price	$ 0.0900
Total Options Premium inflow to the Writer = $0.035 + $0.040	$0.0750
Net Loss	$0.0150

3. Increase in Prices- Strategy

As Expected Future Price is higher, purchase of call option is beneficial. (Otherwise, put option may be sold).

Course of Action-

1. Contract Date: 19th July: Pay Premium for USD 14,00,000 @ Rs. 0.12 per USD = INR 1,68,000.
2. Exercise Date: 19th December: Exercise Call – Gain = 14,00,000 × Rs. (45.00 – 44.80) = INR 2,80,000.
3. Net Gain or Profit = (1) – (2) = INR 1,12,000.

Illustration 55

Fund Managers anticipate a big move in the stock of Bikram Ltd. Anup of ABC Fund believes such change to be upwards, while Shyam of Premier Fund holds the opposite view.

From the following information made available of Bikram Ltd, explain what action will Anup and Shyam take and why?

Exercise Price	Premium for Call Option	Premium for Put Option
₹100	₹15	₹10

Solution:

A. Anup, ABC Fund

1. Choice of Strategy:

(a) Outlook: Extreme Volatility and uncertain future. Stock of Bikram Ltd expected to appreciate i.e. Bullish on Bikram.

(b) Strategy: Creation of Strap i.e. Buying Two Calls, Buying One Put

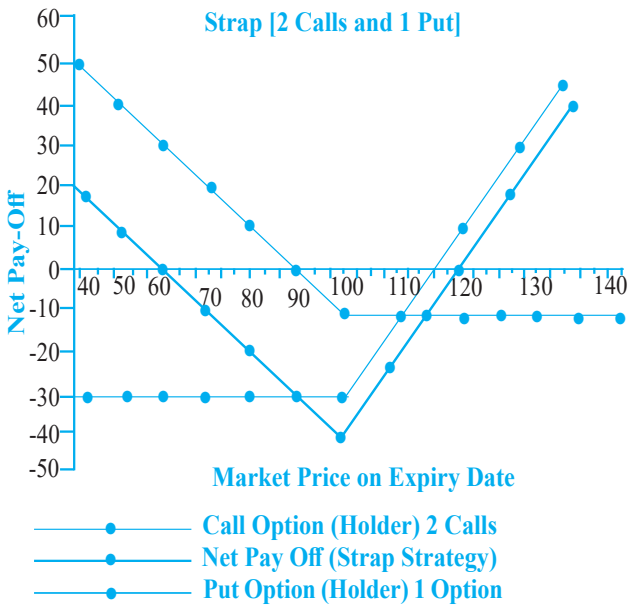
(c) Why? Increase in price is more likely than decrease, therefore two calls would yield better results. Put option is bought to cash in if stock of Bikram spirals downwards.

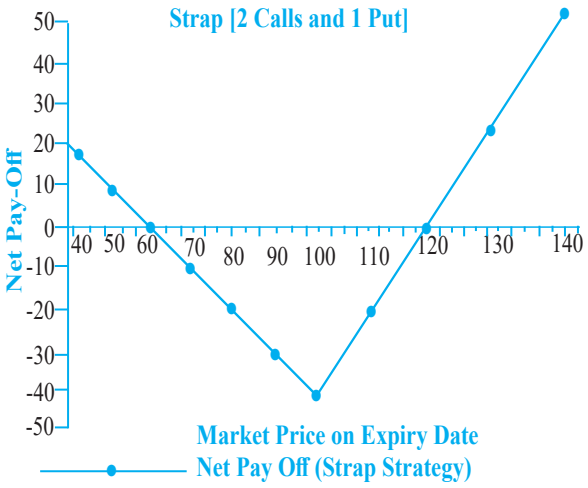
2. Pay off Table:

Price on Expiry Date	Call Option [2 Options]				Put Option (1 Option]				Net Pay off ₹
	Ex. Price ₹	Premium ₹	Action	Payoff	Ex. Price ₹	Premium ₹	Action	Payoff ₹	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10) = (5) + (9)
40	100	15	Lapse	(30)	100	10	Exercise	50	20
50	100	15	Lapse	(30)	100	10	Exercise	40	10
60	100	15	Lapse	(30)	100	10	Exercise	30	0
70	100	15	Lapse	(30)	100	10	Exercise	20	(10)
80	100	15	Lapse	(30)	100	10	Exercise	10	(20)

90	100	15	Lapse	(30)	100	10	Exercise	0	(30)
100	100	15	Lapse	(30)	100	10	Lapse	(10)	(40)
110	100	15	Exercise	(10)	100	10	Lapse	(10)	(20)
120	100	15	Exercise	10	100	10	Lapse	(10)	0
130	100	15	Exercise	30	100	10	Lapse	(10)	20
140	100	15	Exercise	50	100	10	Lapse	(10)	40

3. Pay off Graphs:





B. Shyam, Premier Fund

1. Choice of Strategy:

(a) Outlook: Extreme Volatility and uncertain future. Stock of Shyam Premier Fund expected to depreciate i.e. Bearish on Shyam.

(b) Strategy: Creation of Strip i.e. Buying Two Puts, Buying One Call.

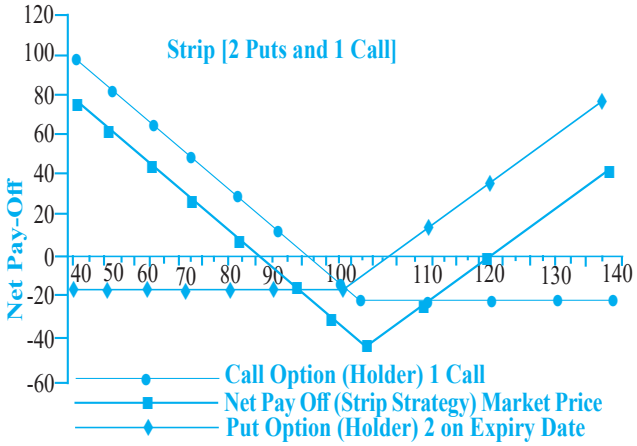
(c) Why? Decrease in price is more likely than increase; therefore two puts would yield better results as prices go down. One Call option is bought to cash in if stock of Shyam spirals upwards.

2. Pay off Table:

Price on Expiry Date	Call Option [1 Option]				Put Option [2 Options]				Net Payoff (₹)
	Ex. Price (₹)	Premium (₹)	Action	Payoff	Ex. Price (₹)	Premium (₹)	Action	Payoff (₹)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10) = (5) + (9)
40	100	15	Lapse	(15)	100	10	Exercise	100	85
50	100	15	Lapse	(15)	100	10	Exercise	80	65
60	100	15	Lapse	(15)	100	10	Exercise	60	45
70	100	15	Lapse	(15)	100	10	Exercise	40	25

80	100	15	Lapse	(15)	100	10	Exercise	20	5
90	100	15	Lapse	(15)	100	10	Exercise	0	(15)
100	100	15	Lapse	(15)	100	10	Lapse	(20)	(35)
110	100	15	Exercise	(5)	100	10	Lapse	(20)	(25)
120	100	15	Exercise	5	100	10	Lapse	(20)	(15)
130	100	15	Exercise	15	100	10	Lapse	(20)	(5)
140	100	15	Exercise	25	100	10	Lapse	(20)	5

3. Pay off Graphs:



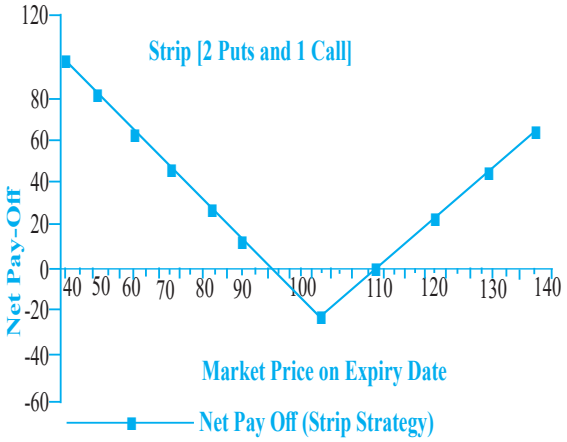


Illustration 56

Ascertain the value of Call Options expiring one year later, of four securities from the following information –

Stock	Current Spot Price (₹)	Exercise Price (₹)	Expected Price One Year Later (₹)
X Ltd	1,020	1,050	1,100
Y Ltd	200	180	220
Z Ltd	500	510	535
D Ltd	80	80	90

Risk Free Rate may be assumed at 10% for continuous discounting. Also show in case of Security Z, how choosing the Stock Route and Option Route with Risk Free Investment will have the same wealth for an investor at the end of the year for the same cash outgo.

Solution :

1. Computation of Value of Call

Stock	Current Spot Price [SP_0] (₹)	Exercise Price [EP] (₹)	PV of EP [EP × $e^{-1\times0.10}$] (₹)	Value of Call Option [SP_0 – PV of EP] (₹)
(1)	(2)	(3)	(4)	(5) = (2) – (4)
X	1,020	1050	1050÷1.1052 = 950.05	1,020 – 950.05 = 69.95
Y	200	180	180÷1.1052 = 162.87	200 – 162.87 = 37.13
Z	500	510	510÷1.1052 = 461.45	500 – 461 .45 = 38.55
D	80	80	80÷1.1052 = 72.39	80 – 72.39 = 7.61

2. Case of Stock of Z Ltd.

Action on Stock Route	Action on Option Plus Risk Free Return Route
Now: Buy Stock of Z at ₹500	Now: • Invest Present Value (i.e. ₹461.45) of Exercise Price at Risk Free Rate of 10% (continuous compounding) • Buy Call Option at ₹38.55 (Strike Price of ₹510) • Total Cash Outgo = ₹461.45 + ₹38.55 = ₹500
1 Year Later: net worth = Value per Share at Expected Future Spot Rate = ₹535	1 Year Later: • Net worth = Maturity Value of Risk Free Investment + Value of Call Option • Maturity Value of Risk Free Investment = ₹461.45 × $e^{1\times0.10}$ = ₹510 • Value of Call Option (on Expiry) = Gain on Exercise of Option = Spot Price on Expiry Date Less Exercise Price = ₹535 – ₹510 = ₹25 • Net Worth = ₹510 + ₹25 = ₹535

Illustration 57

Ascertain the value of Options expiring one year later, for the following securities-

1. ABC Ltd (ABCL) is quoted at ₹110. At the end of 3 Months, the stock price will either be ₹100 or ₹150. Exercise price is ₹120
2. 3-Month Options on MN Ltd (MNL) carry an exercise price of ₹350. Stock Price is expected to be ₹250 or ₹450. Presently the shares are traded for ₹380.

Risk Free Rate may be assumed at 12% for continuous discounting.

Solution:

1. ABC Ltd

(a) Basic Data

Particulars	₹
Stock Price (SP_0)	110
Exercise Price (EP)	120
Expected Future Spot Price on Expiry Date	
• Future Price 1 [FP_1]	100
• Future Price 2 [FP_2]	150

(b) Computation of Option Delta:

Particulars	FP_1	FP_2
Future Spot Price (₹)	100	150
Position on Expiry Date (in comparison with Exercise Price)	Out of Money	In the Money
Action on Expiry Date	Lapse	Exercise
Value of Option on Expiry [Future Spot Price Less Exercise Price](₹)	–	₹30 [150-120]

Option Delta = Change in Value of Option ÷ Change in Future Spot Price
= (₹30 – 0) ÷ (₹150 – ₹100) = ₹30/₹50 = 0.60

(c) Computation of Amount to be Invested at Risk Free Rate:

= Present Value of Lower Bank of Future Spot Price i.e. FP_1

= Present Value of ₹100 discounted at 12% Continuous Compounding for a 3-Month Period

= ₹100 × e^{rt}

= ₹100 ÷ $e^{0.12\times0.25}$ = ₹100 ÷ 1.0305 = ₹97.04

(d) Value of Call [C]

= Option Delta × [Current Stock Price Less Amount to be invested at Risk Free Rate]

= 0.60 × (₹110 – ₹97.04) = 0.60 × ₹12.96 = ₹7.78

(e) Value of Put [P] (Under Put Call Parity)

→ Value of Call + Present Value of Exercise Price = Current Spot Price + Value of Put

→ C + EP × e^{-rt} = SP_0 + P

→ ₹7.78 + (₹120 ÷ 1.0305) = ₹110 + P

→ P = ₹7.78 + ₹116.45 – ₹110 = ₹14.23

2. MN Limited

(a) Basic Data

Particulars	₹
Stock Price (SP_0)	380
Exercise Price (EP)	350
Expected Future Spot Price on Expiry Date	
• Future Price 1 [FP_1]	250
• Future Price 2 [FP_2]	450

(b) Computation of Option Delta

Particulars	FP_1	FP_2
Future Spot Price (₹)	250	450
Position on Expiry Date (in comparison with Exercise Price)	Out of Money	In the Money
Action on Expiry Date	Lapse	Exercise
Value of Option on Expiry [Future Spot Price Less Exercise Price] (₹)	₹0	₹100 [450-350]

Option Delta = Change in value of options ÷ Change in future spot Price
= (₹100-0) ÷ (₹450 – ₹250) = ₹100 / ₹200 = 0.50

(c) Computation of Amount to be Invested of Risk Free Rate:

= Present Value of Lower Band of Future Spot Price i.e. FP_1

= Present Value of ₹250 discounted at 12% Continuous Compounding for a 3-Month Period

= ₹250 × e^{-rt} = ₹250 ÷ e^{rt}

= ₹250 ÷ e $^{0.12\times0.25}$ = ₹250 ÷ 1.0305 = ₹242.60

(d) Value of Call [C]

= Option Delta × [Current Stock Price Less Amount to be invested at Risk Free Rate]

= 0.50 × (₹380 – ₹242.60) = 0.50 × ₹137.40 = ₹68.70

(e) Value of Put [P] (Under Put Call Parity):

→ Value of Call + Present Value of Exercise Price = Current Spot Price + Value of Put

→ $C + EP \times e^{-rt} = SP_0 + P$

→ ₹68.70 + (₹350 ÷ 1.0305) = ₹380 + P

→ P = ₹68.70 + ₹339.64 – ₹380 = ₹28.34.

Illustration 58

Stock of Kamla Woodwork is currently quoted at ₹110. In three month's time it could either be ₹90 or ₹135. Ascertain the value of Call Option with an exercise price of ₹120 if the risk free rate of return is 8%.

Solution:

1. Basic Data

Factor	Notation	Value
Spot Price	SP_0	₹110
Exercise Price	EP	₹120
Expected Future Spot Price – Lower Limit [FP_1]	FP_1	₹90
Expected Future Spot Price – Higher Limit [FP_2]	FP_2	₹135
Value of Call at Lower Limit [Action = Lapse, since FP_1 < EP. Therefore Value is NIL]	C_d	₹ NIL
Value of Call at Upper Limit [Action = Exercise, since FP_2 > EP. Therefore, Value is FP_2 – EP = ₹135 – ₹120]	C_u	₹15
Extent of Lower Limit of Future Spot Price [FP_1] on Current Price [SP_0] [FP_1/SP_0] = ₹90/₹110	d	0.82
Extent of Upper Limit of Future Spot Price [FP_2] on Current Price [SP_0] [FP_2/SP_0] = ₹135/₹110	u	1.227
Risk Free Rate of Return	r	8%
Tenor of Options Contract [in Years] = 3 Months/ 12 Months	t	0.25
Future Value Factor [Continuous Compounding Factor] = $e^{0.08\times0.25}$	f	1.0202

2. Alternate 1 [Formula Method]

$$= \frac{C_u\left[\frac{f-d}{u-d}\right] + C_d\left[\frac{u-f}{u-d}\right]}{f} = \frac{₹15\times\left[\frac{1.0202-0.82}{1.227-0.82}\right] + ₹0\times\left[\frac{1.227-1.0202}{1.227-0.82}\right]}{1.0202}$$

= [₹15 × (0.200 / 0.407) + 0] / 1.0202

= (₹15 × 0.4919) ÷ 1.0202 = ₹7.232

3. Alternative 2 [Decision Tree Method] [Requires Probability Value]

(a) Computation of Probability of FP_1 and FP_2

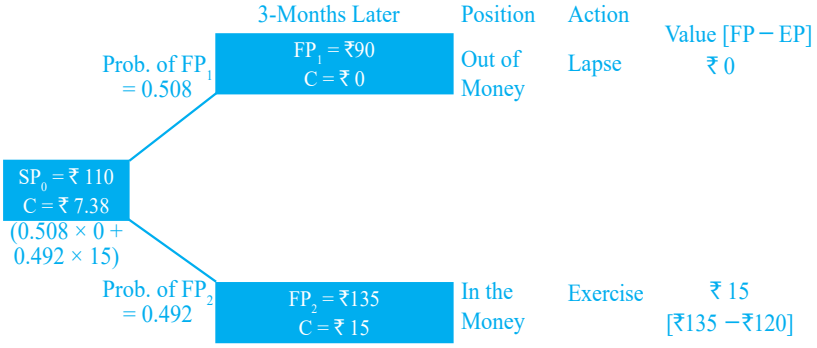
Probability of Lower Limit (FP_1) = (u – f) ÷ (u – d) = (1.227 – 1.0202) / (1.227 – 0.82)

= 0.2068 ÷ 0.407 = 0.508

Probability of Higher Limit (FP_2) = 1 − 0.508

= 0.492

(b) Value of Option [Future Value of Option]



Present Value of Call = Future Value × e^{-rt} or Future Value ÷ e^{rt} = ₹7.38 ÷ 1.0202 = ₹7.23

4. Alternative 3 [Table Method or Delta Route]

Value of Call = No. of Shares per Call Option × [Current Stock Price – Present Value of Lower Limit of Future Spot Price]

= Option Delta × [SP_0 – (FP_1 × e^{-rt})]

= [(15-0)/ (135-90)] × [110 – (90 ÷ 1.0202)]

= [(15/45)] × [110 – 88.22] = 0.3333 × 21.78 = ₹7.26

Illustration 59

Nirmal hydric Ltd. (NHL) is a newly listed Company. Its listing price today is ₹200. Though the industry offers much potential, there are no proven past track records.

Analysts expect the price of NHL to either to rise by 40% every half (on the half yearly opening price), for the next one year, weightage being 40% for every increase and 60% for every fall.

If an One Year option carries a Exercise Price of ₹260, you required to compute the following under Binomial Model –

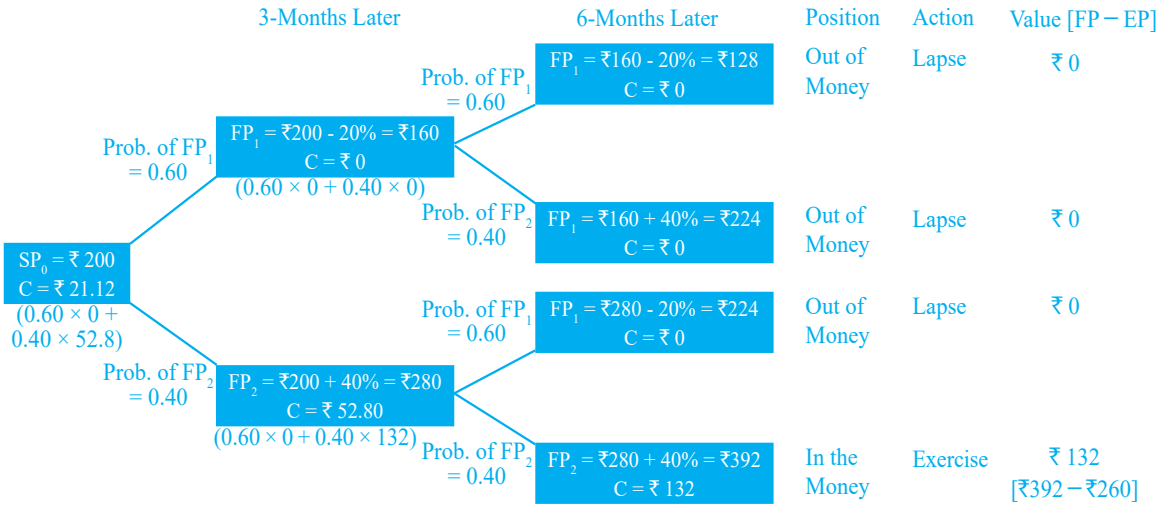
(1) Risk Free Rate of Return,

(2) Value of Call (Future Value and Present Value),

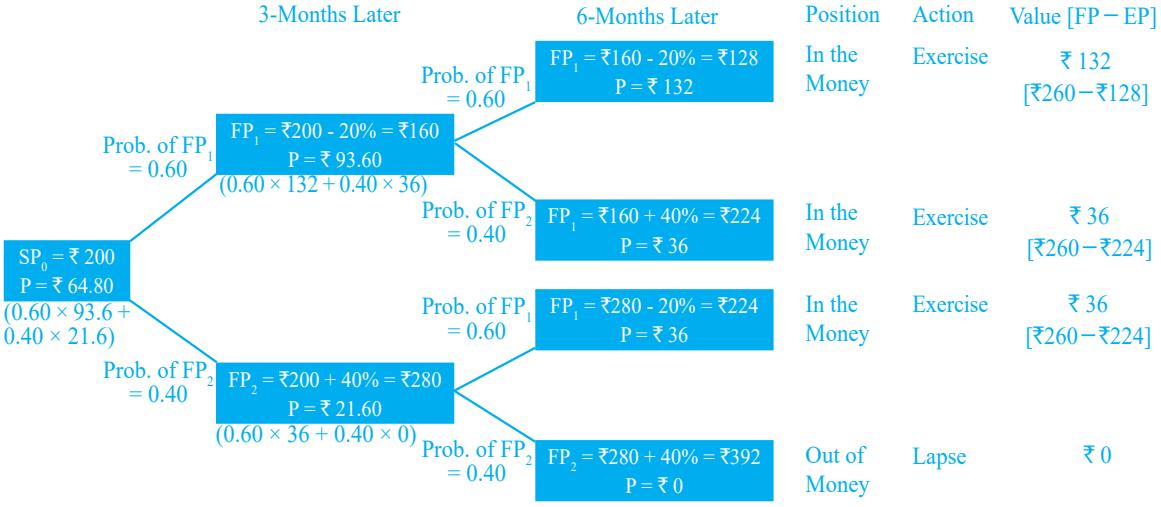
(3) Value of Put (Future Value & Present Value)

Solution:

1. Computation of Future Value of Call



2. Computation of Future Value of Put



3. Computation of Risk Free Rate of Return Basic Data

Factor	Notation	Value
Spot Price	SP_0	₹200
Expected Future Spot Price – Lower Limit [FP_1]	FP_1	₹160
Expected Future Spot Price – Higher Limit [FP_2]	FP_2	₹280
Extent of Lower Limit of Future Spot Price [FP_1] on Current Price [SP_0] [FP_1/ SP_0] = ₹160/₹200	d	0.80
Extent of Upper Limit of Future Spot Price [FP_2] on Current Price [SP_0] [FP_2/ SP_0] = ₹280 /₹200	u	1.40

Risk Free Rate of Return	r	To be ascertained
Tenor of Options Contract [in Years]	t	0.5

(a) Probability of Lower Limit (FP_1) = 0.60

→ 0.60 = (u − f) ÷ (u − d) = (1.40 – f) / (1.40 – 0.80) = (1.40 – f) / 0.60

→ 0.60 × 0.60 = 1.40 – f

→ f = 1.40 – 0.36 = 1.04

→ e^{rt} = 1.04

→ $e^{r \times 0.50}$ =1.04 (Since per time slot = 6 Months or 0.25 Years)

(b) Computation of Risk Free Rate:

From Natural Log Table, 1.04 is the value for 0.040

→ Log $e^{0.5r}$ = Log 1.04^0

→ 0.5r = 0.0392

→ r = 0.0392 ÷ 0.5 = 0.0784 or 7.84% p.a.

4. Present Value of Options

(a) Call Option: Future Value × e^{-rt}, where r = 7.84% and t = 1 Year

= ₹21.12 × $e^{-0.0784}$

= ₹21.12 ÷ $e^{0.0784}$

= ₹21.12 ÷ 1.0815

= ₹19.53

(b) Put Option: Future Value × e^{-rt}, where r = 7.84% and t = 1 Year

= ₹64.80 × $e^{-0.0784}$ = ₹64.80 ÷ $e^{0.0784}$ = ₹64.80 ÷ 1.0815 = ₹59.92

Under Put Call Parity = P = C + PV of EP – SP_0

= 19.53 + (260 ÷ 1.0815) – 200 = 19.53 + 240.40 – 200 = ₹59.93

Illustration 60

Trie market received rumor about XYZ Corporation's tie – up with a multinational company. This has induced the market price to move up. If the rumor is false , the XYZ Corporation's 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 strike price of ₹42 for ₹2 premium, and paid ₹1 per share premium for a 3 months put with a strike price of ₹40.

(a) Determine the investor's position if the tie up offer bids the price of XYZ Corporation's stock up to ₹44 in 3 months

(b) Determine the investor's ending position, if the tie up programme fails and the price of the stocks falls to ₹35 in 3 months

Solution:

1. Cost of Call and Put options

Cost of Call and Put Options = (₹2 per share Call)+(₹1 per share put)

= ₹2 + ₹1 = 3

2. Position if Price increases to ₹44

Particulars	Time	₹
(a) Cost of Options	T_0	3
(b) If Price Increases to ₹44, Investor will not exercise the Put Option, Gain on Call [Spot Price on Expiry Date – Exercise Price = ₹44 – ₹42]	T_1	2
(c) Net Loss due to Options [(a) – (b)]	T_1	1

3. Position if Price falls to ₹35

Particulars	Time	₹
(a) Cost of Options	T_0	3
(b) If Price falls to ₹35, Investor will not exercise the call Option. Gain on Put [Exercise Price – Spot price on expiry date = ₹40 – ₹35]	T_1	5
(c) Net Gain due to Options [(b) – (a)]	T_1	2

Illustration 61

Calculate the price of a three –month European put option on a non dividend - paying stock with a strike price of ₹50 when the current stock price is ₹50, the risk –free interest rate is 10% per annum, and the volatility is 30% per annum

Solution:

Black and Scholes also developed formula for determining the price of a put option and the formula is as follows:

$P = Ke^{-rt} N(-d_2) - S_0 N(-d_1)$

Where P denotes price of the Put Option.

S_0 is spot price of the underlying stock

K is the strike price of the option

T denotes time to expiration of option expressed in year

r is the risk- free rate of interest

$Ln(d_1)$ denotes the cumulative probability up to d_1 (i = 1, 2) following standard normal distribution,

$d_1 = [Ln(S_0/k) + (r + \sigma^2/2)T] / \sigma\sqrt{T}$; σ is the volatility of the price of underlying stock

and $d_2 = d_1 - \sigma\sqrt{T}$

In the above illustration, S_0 = ₹50, K= ₹50, T = 3/12 = ¼ = 0.25. r = 0.10, σ = 0.30

$d_1 = [Ln(50/50) + (0.10 + 0.09 / 2).025] / 0.30\sqrt{0.25} = 0.2417$

$d_2 = d_1 - 0.30\sqrt{0.25} = 0.0917$

The European Put rice is

$50\ e^{-0.10 \times 0.25} N(-0.0917) - 50N(-0.2417)$

$= 50\ e^{-0.10 \times 0.25} \times 0.463 - 50 \times 0.4045$

$= 2.37$

Illustration 62

What difference does it make to your calculation in previous Illustration if a dividend of ₹1.50 is expected in two months?

Solution:

In this case we must subtract the present value of the dividend from the stock price before using Black – Scholes

Hence the appropriate value of S_0 is

$$S_0 = 50 - 1.50\ e^{-0.1667 \times 0.10} = 48.52$$

As before , K= ₹50, T = 3/12 = 1/4 = 0.25, r = 0.10, σ = 0.30

$d_1 = [Ln(48.52/50) + (0.10+0.09/2)0.25] / 0.30\sqrt{0.25} = 0.0414$

$d_2 = d_1 - 0.30\sqrt{0.25} = -0.1086$

The European put price is

$50\ e^{-0.10 \times 0.25}\ N(-0.1086) - 48.52\ N(-0.0414)$

$= 50\ e^{-0.10 \times 0.25} \times 0.532 - 48.52 \times 0.4835$

$= 2.48$

Illustration 63

Consider a European call option on a stock when there are ex-dividend dates in two months and five months. The dividend on each ex-dividend date is expected at be ₹0.50. The current share price is ₹40, the exercise price is ₹40, the stock price volatility is 30% per annum, the risk-free rate of interest is 9% per annum, and the time to maturity is six months. Find out the European call price.

Solution:

Black and Scholes developed formula for determining the price of a call option and the formula is as follows:

$C = S_0N(d_1) - K^{e-rt}\ N(d_2)$

where C denotes price of the call option,

S_0 is spot price of the underlying stock,

K is the strike price of the option,

t denotes time to expiration of option expressed in year, ,

r is the risk - free rate of interest,

$N(d_1)$ denotes the cumulative probability up to d_1 (i = 1, 2) following standard normal distribution,

$d_1 = [Ln(S_0/K) + (r + \sigma^2/2)t]\ \sigma\sqrt{t}$; σ is the volatility of the price of underlying stock,

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

In this case the present value of the dividend is subtracted from the stock price before using Black - Scholes. The

present value of the dividends is

$= 0.5e^{-0.1667 \times 0.09} + 0.5e^{-0.4167 \times 0.09} = 0.9741$

The option price can therefore be calculated form the Balck - Scholes formula with $S_0 = 40 - 0.9741 = 39.0259$, K = 40, r = 0.09, $\sigma = 0.3$, and T = 0.5. We have

$$d_1 = \frac{Ln(39.0259/40) + (0.09 + 0.3^2/2) \times 0.5}{0.3\sqrt{0.5}} = 0.2017$$

$$d_1 = \frac{Ln(39.0259/40) + (0.09 - 0.3^2/2) \times 0.5}{0.3\sqrt{0.5}} = -0.0104$$

$N(d_1) = 0.5800$, $N(d_2) = 0.4959$

The call price is:

$39.0259 \times 0.5800 - 40e^{-0.09 \times 0.5} \times 0.4959 = 3.67$

Illustration 64

What is the price of a European put option on a non-dividend-paying stock when the stock price is ₹ 69, the strike price is ₹ 70, the risk-free interest rate is 5% per annum, the volatility is 35% per annum, and the time to maturity is six months?

Solution:

In this case,

$S_0 = 69$, K = 70, r = 0.05, $\sigma = 0.35$ and T = 0.5

$$d_1 = \frac{Ln(69/70) + (0.05 + 0.35^2/2) \times 0.5}{0.35\sqrt{0.5}} = 0.166$$

$d_2 = d_1 - 0.35\sqrt{0.5} = -0.0809$

The price of the European put is

$70e^{-0.05 \times 0.5} N(0.0809) - 69 N(-0.1666)$

$= 70e^{-0.05 \times 0.5} \times 0.5323 - 69 \times 0.4338$

$= 6.40.$

Swaps

13.4

13.4.1 Meaning, Features, Types, Benefits of Swaps

⊙ Concept of Swap

A swap is an agreement between two parties to exchange sequences of cash flows for a set period of time. Usually, at the time the contract is initiated, at least one of these series of cash flows is determined by a random or uncertain variable, such as an interest rate, foreign exchange rate, equity price or commodity price. Conceptually, one may view a swap as either a portfolio of forward contracts, or as a long position in one bond coupled with a short position in another bond.

Unlike most standardized options and futures contracts, swaps are not exchange-traded instruments. Instead, swaps are customized contracts that are traded in the over-the-counter (OTC) market between private parties. Firms and financial institutions dominate the swaps market, with few (if any) individuals ever participating. Since swaps occur on the OTC market, there is always the risk of a counterparty defaulting on the swap.

Swap is a combination of forwards by two counterparties. It is arranged to reap the benefits arising from the fluctuations in the market - either currency market or interest rate market or any other market for that matter.

⊙ Features of Swap:

The following are the important features of a swap:

a. Counter parties: Swaps involve the agreement between two or more parties to exchange cash flows or the parties interested in exchanging the liabilities.

b. Facilitators: The amount of cash flow exchange between parties is huge and also the process is complex. Therefore, to facilitate the transaction, an intermediary comes into picture which brings different parties together for big deal. These may be brokers whose objective is to initiate the counterparties to finalize the swap deal. While swap dealers are themselves counter partied who bear risk and provide portfolio management service.

c. Cash flows: The present values of future cash flows are estimated by the counterparties before entering into a contract. Both the parties want to get assurance of exchanging same financial liabilities before the swap deal.

d. Less documentation: Since these are not exchange traded, the requirement for documentation is comparatively low.

e. Transaction costs: Swap involves a transaction cost in form of commission to the intermediary. However, transaction costs are found to be relatively low in swaps.

f. Benefit to both parties: The swap agreement is undertaken only when there is mutual benefit.

g. **Termination:** Since it is an agreement between two parties, it cannot be terminated at one's instance. The termination is required to be accepted by the counter party.

h. **Default-risk:** Since swaps are mostly bilateral not exchange traded like futures or options, default risk is higher in swaps.

⊙ **Types of Financial Swaps**

Major types of financial swaps include the following.

a. **Interest Rate Swaps:** An interest rate swap, or simply a rate swap, is an agreement between two parties to exchange a sequence of interest payments without exchanging the underlying debt.

b. **Currency Swaps:** Cross currency swaps are agreements between counter-parties to exchange interest and principal payments in different currencies. In a currency swap, these streams of cash flows consist of a stream of interest and principal payments in one currency exchanged for a stream, of interest and principal payments of the same maturity in another currency. Due to the exchange and re-exchange of notional principal amounts, the currency swap generates a larger credit exposure than the interest rate swap.

c. **Equity Swaps:** An equity swap is a special type of total return swap, where the underlying asset is a stock, a basket of stocks, or a stock index. In an equity swap, there is an exchange of the potential appreciation of equity's value and dividends for a guaranteed return plus any decrease in the value of the equity.

d. **Credit Default Swaps:** Credit Default Swap is a financial instrument for swapping the risk of debt default. Credit default swaps may be used for emerging market bonds, mortgage- backed securities, corporate bonds and local government bond. The buyer of a credit default swap pays a premium for effectively insuring against a debt default. He receives a lump sum payment if the debt instrument is defaulted. The seller of a credit default swap receives monthly payments from the buyer. If the debt instrument defaults, they have to pay the agreed amount to the buyer of the credit default swap.

We have discussed, in detail, the Interest Rate Swaps and Credit Default Swaps in this section. For Currency Swaps, please refer to Module 15 of this Study Material.

⊙ **Benefits of Swap:**

The following advantages can be derived by a systematic use of swap:

a. **Borrowing at Lower Cost:**

Swap facilitates borrowings at lower cost. It works on the principle of the theory of comparative cost as propounded by Ricardo. One borrower exchanges the comparative advantage possessed by him with the comparative advantage possessed by the other borrower. The net result is that both the parties are able to get funds at cheaper rates.

b. **Access to New Financial Markets:**

Swap is used to have access to new financial markets for funds by exploring the comparative advantage possessed by the other party in that market. Thus, the comparative advantage possessed by parties is fully exploited through swap. Hence, funds can be obtained from the best possible source at cheaper rates.

c. **Hedging of Risk:**

Swap can also be used to hedge risk. For instance, a company has issued fixed rate bonds. It strongly feels that the interest rate will decline in future due to some changes in the economic scene. So, to get the benefit in future from the fall in interest rate, it has to exchange the fixed rate obligation with floating rate obligation. That is to say, the company has to enter into swap agreement with a counterparty, whereby,

it has to receive fixed rate interest and pay floating rate interest. The net result is that the company will have to pay only floating rate of interest. The fixed rate it has to pay is compensated by the fixed rate it receives from the counterparty. Thus, risks due to fluctuations in interest rate can be overcome through swap agreements. Similar, agreements can be entered into for currencies also.

d. Tool to correct Asset-Liability Mismatch:

Swap can be profitably used to manage asset-liability mismatch. For example, a bank has acquired a fixed rate bearing asset on the one hand and a floating rate of interest-bearing liability on the other hand. In case the interest rate goes up, the bank would be much affected because with the increase in interest rate, the bank has to pay more interest. This is so because, the interest payment is based on the floating rate, but the interest receipt will not go up, since, the receipt is based on the fixed rate. Now, the asset- liability mismatch emerges. This can be conveniently managed by swap. If the bank feels that the interest rate would go up, it has to simply swap the fixed rate with the floating rate of interest. It means that the bank should find a counterparty who is willing to receive a fixed rate interest in exchange for a floating rate. Now, the receipt of fixed rate of interest by the bank is exactly matched with the payment of fixed rate interest to swap counterparty. Similarly, the receipt of floating rate of interest from the swap counterparty is exactly matched with the payment of floating interest rate on liabilities. Thus, swap is used as a tool to correct any asset- liability mismatch in interest rates in future.

e. Additional Income:

By arranging swaps, financial intermediaries can earn additional income in the form of brokerage.

13.4.2 Interest Rate Swaps, Credit Default Swaps

13.4.2.1 Interest Rate Swaps

⊙ **Concept of Interest Rate Swaps**

An interest rate swap is a financial contract between the two parties who want to exchange the interest payments or receipts in the same currency on assets or liabilities to a different basis. There is no exchange of principal amount here. In other words, it is an exchange of interest payment for a specific maturity on an agreed upon notional amount. Here, the term 'notional' refers to the theoretical principal underlying the swap. The principal amount applies only for the purpose of calculating the interest to be exchanged under an interest rate swap.

The simplest example of interest rate swap is the exchange of fixed for floating rate interest payments between two parties in the same currency. This is also known as plain vanilla swap, or coupon swap. It involves credit differentials between two borrowers in the fixed and floating debt markets which generate substantial cost savings for both the counter parties.

⊙ **Features of interest rate swaps**

The key features of interest rate swaps are stated as follows:

a. Notional principal: In the interest rate swap agreement, the interest amount whether fixed or floating is calculated on a specified amount borrowed or lent. It is notional because the parties do not exchange this amount at any time.

b. Fixed rate: This is the rate, which is used to calculate the size of the fixed payment. Banks or the other financial institutions who make market in interest rate swaps quote the fixed rate, they are willing to pay if they are fixed rate payers in a swap (bid swap rates), they are willing to receive if they are floating rate payers in a swap (ask swap rate). For example, a bank might quote a US dollar floating to fixed 5-year swap rate:

(Treasuries + 20 bp)/(Treasuries + 40 bp) as against a six-month LIBOR.

This quote may be interpreted as follows:

(i) The said bank is willing to make fixed payment at a rate equal to the current yield on Five-year treasury notes plus 20 basis points (0.20 percent) in return for receiving floating payments, say at six-month LIBOR.

(ii) The bank has offered to accept at a rate equal to Five-year treasury notes plus 40 basis points in return for payment of six-month LIBOR.

c. Floating rate: Floating rate in swaps is determined on the basis of market indexes like LIBOR, MIBOR, Treasury Bill rate, etc.

⊙ Interest Rate Swap Mechanism

Suppose, there are two firms X and Y. Firm X is an institution that invests $100 million in fixed rate mortgages yielding 9.5 percent. Assume firm X is not the high rated firm and funding its assets through a floating rate loan from the banks, i.e., charging six-month London Inter Bank Offer Rate (LIBOR) plus 5 basis point (a basis equals 0.01 percent). It means that firm X's profitability depends upon the actual level of the floating interest rate in future that is to be paid over the long run. Therefore, if fluctuation in interest rates will be high then firm X's debt service expenses will increase, consequently the profit will decline. In other words, firm X will lose money whenever LIBOR exceeds 9 percent (9.50 – 0.50).

Suppose, another Firm Y, has also borrowed $ 100 million for five years but at a fixed rate. Assume that firm Y is high graded firm and is funding its loan portfolio at 7.25 percent coupon. Firm Y's portfolio is yielding LIBOR plus 75 basis points. It means Firm Y's profitability depends upon the actual floating interest rate that is received on its portfolio. Whenever, LIBOR is less than 6.50 percent (7.25 – 0.75), Firm Y is losing money. This situation is shown in the following table.

Firm X	Firm Y
Mortgage Portfolio: $100 million portfolio with 5-year average maturity	Loan Portfolio: $100 million portfolio with 5-year average maturity
Yield: 9.5%	Yield: LIBOR + 0.75%
Borrowed at: LIBOR + 0.5%	Borrowed at: 7.25%

In order to eliminate interest rale risk, Firm X may enter into interest rate swap deal with Top Bank. Assume that 7.50 percent will be paid by Firm X to Top Bank for five years with payments calculated by multiplying that rate by $100 million, the notional principal amount. In return, Top Bank agrees to pay Firm X six-month LIBOR over five years.

The result for the same is as follows:

Receipt on Portfolio	9.5%
Pay to Top Bank	7.5%
Receive from Top Bank	LIBOR
Pay on loan	LIBOR + 0.5%
Cost of fund	7.5% + 0.5% = 8%
Locked in spread = Receipt on Portfolio – Cost of Fund	1.5%

Similarly, Firm Y will enter into a swap deal with Top Bank where it agrees to pay six-month LIBOR to Top Bank on a notional principal amount of $100 million for five years in exchange for receiving payments of 7.40%. the net result is shown below.

Receipt on Portfolio	LIBOR + 0.75%
Pay to Top Bank	LIBOR
Receive from Top Bank	7.4%
Pay on Euro Bond	7.25%
Cost of fund	LIBOR +7.25% – 7.40% = LIBOR – 0.15%
Locked in spread = Receipt on Portfolio – Cost of Fund	0.90%

In this swap deal, the interest of Top Bank should also be assessed. For Top Bank the result can be summarized as follows:

Received from X	7.5%
Pay to Y	7.4%
Receive from Y	LIBOR
Pay to X	LIBOR
Net gain	0.10%

Thus, Top Bank receives (100 million × 0.10%) = $1,00,000 as the compensation from the swap deals.

⊙ **Types of Interest Rate Swaps**

a. **Plain vanilla swap:** It is also known as fixed-for-floating swap. In this swap, one party with a floating interest rate liability is exchanged with fixed rate liability.

b. **Zero coupon to floating:** In a zero-coupon bond, the holders get the full amount of loan and interest accrued only at the maturity of the bond. Hence, in this swap, the fixed rate player makes a bullet payment at the end and floating rate player makes the periodic payment throughout the swap period.

c. **Alternative floating rate:** In this type of swap, the floating reference can be switched to other alternatives as per the requirement of the counter party. These alternatives may include three-month LIBOR, one-month commercial paper, T-Bill rate, etc. In other words, alternative floating interest rates are charged in order to meet the exposure of other party.

d. **Floating-to- floating:** In this swap, one counter party pays one floating rate, say, LIBOR while the other counter party pays another, for a specified time period. These swap deals are mainly used by the non-US banks to manage their dollar exposure.

e. **Forward swap:** This swap involves an exchange of interest rate payment that does not begin until a specified future point in time. It is also a kind of swap involving fixed for floating interest rate.

f. **Rate-capped swap:** It is similar to fixed to floating rate swap, whereby the floating rate payments are capped. An upfront fee is paid by floating rate party to fixed rate party for the cap.

g. **Extendable swap:** It contains an extendable feature, which allows the parties to extend the swap period.

Swaptions – An Innovation

Swaptions are combination of the features of two derivative instruments, i.e., option and swap. Option interest rate swaps are referred as swaptions. The buyer of the swaption has the right to enter into an interest rate swap agreement by some specified date in the future. The swaption agreement will specify whether the buyer of the swaption will be a fixed rate receiver or a fixed rate payer. If the buyer exercises the option, then the writer of the option will become the counter party.

Swaption can be of two types: Call swaption or callable swap and put swaption or puttable swap. A callable swap provides the party making the fixed payments with the right to terminate the swap to its maturity. The writer, therefore, becomes the fixed rate receiver and floating rate payer. On the other hand, a puttable swap provides the party making the floating rate payments with a right to terminate the swap. The writer of the put swaption, therefore, becomes the floating rate receiver and fixed rate payer.

⊙ Valuation of Interest Rate Swaps

While valuing the plain vanilla interest rate swap, the fixed leg should be considered a fixed coupon bond and the floating rate should be considered a floating rate note.

Considering that at maturity level the fixed and floating parties give each other equal amount of money, the pricing of the swap becomes simply the value of the fixed coupon bond minus the value of the floating rate note. This is denoted by formula given below:

$V = F_B - F_F$

Where,

V = Value of the swap

F_B = Value of fixed coupon bond

F_F = Value of floating rate note.

In the above said formula, the values of both the fixed leg and the floating leg swaps will be different as market rates change after the initial pricing of the swap. On the fixed leg, the cash flows do not change but the discount factor changes and hence the value. While on the floating side, both the cash flows and the discounting factor change and hence the value change. Such kind of swap called an off-market swap. This states that the value of an off-market swap can be either positive or negative but not zero.

Consider the following illustration.

Illustration 65

A bank has agreed to pay six-month LIBOR and receive 8 percent per annum (with semi-annual compounding) on a notional principal of $100 million. The swap has a remaining life of 1.25 years. The relevant fixed rate of interest with continuous compounding for 3-month, 9-month and 15-month maturities are 10 percent, 10.5 percent and 11.0 percent respectively. The six-month LIBOR rate at the last payment date was 10.2 percent (with semi-annual compounding). The periodic fixed payment and floating payment are $4.0 million and $5.1 million respectively. Calculate the value of the swap.

Solution:

$F_B = 4e^{-0.25 \times 0.1} + 4e^{-0.75 \times 0.105} + 4e^{-1.25 \times 0.11} + 100e^{-1.25 \times 0.11} = \$98.24$ million

$F_F = 5.1e^{-0.25 \times 0.1} + 100e^{-0.25 \times 0.1} = \$102.51$ million

Hence, the value of swap = 98.24 − 102.51 = (−) $4.27 million.

If the bank takes the opposite position of paying fixed and receiving floating, the value of the swap then would be (+) $4.27 million.

Illustration 66

United Bankers Ltd offer the following interest rates to two of its customers for a loan of ₹100 crores, repayable in 7 years –

Company	Somnath Ltd	Amal IT Services Ltd
Nature of Activity	Supply and Installation of Security Systems for Home, Office, Corporate Surveillance and other Security Services and products	Providing IT support to various Airlines, Shipping Companies and Government Companies
Years in Industry	25	1.5
Market Position	Market Leaders	Market Entrants (Infants)
Rating by UBL	A++	B+
Floating Interest Rate	MIBOR - 0.50%	MIBOR +1%
Fixed Interest Rate	10.00%	12.50%
Share in the net Gain on account of Interest Rate Swap	60%	40%

Assuming, principal amount is repaid at the end of the seven years, what is the effective gain in percentage as well as in value for both the companies, if they enter into a Swap Agreement for reducing interest effect.

Also ascertain the net interest cost (in %) for both the companies.

Solution:

Note: For effecting a swap agreement, choice of interest rates with the respective bankers will be based on the rate of advantage to the stronger company in different interest rate schemes. Expectation on economy or on movement of interest rates are not relevant for structuring a swap agreement.

1. Action and Net Cost

Somnath has an advantage of 2.50% in Fixed Rate (10% vs.12.50%) and 1.50% in floating rate. Therefore, Somnath enjoys a higher advantage in Fixed Rates Loan. Therefore, Somnath Ltd will opt for Fixed Rate Loans with its bankers. Correspondingly Amal Ltd. will opt for Floating RATE Loans with its bankers.

Somnath	Amal
Somnath will borrow at fixed rate	Amal will borrow at floating rate.
Pay interest to bankers at fixed rate (i.e.,10%) [outflow]	Pay interest to its bankers at floating rate (i.e., MIBOR+1%) [outflow].
Will collect from/pay to Amal Interest amount differential i.e., interest computed at Fixed rate (10%) less Interest computed at Floating rate (MIBOR − 0.5%) i.e., (10.50% − MIBOR) [inflow]	Will pay to/collect from Somnath interest amount differential i.e., interest computed at Fixed rate to Somanth (10%) Less Interest Computed at floating rate to Somnath (MIBOR − 0.50%) i.e., (10.50% − MIBOR) [Outflow]
Will collect from Amal share in the gain on account of interest rate swap i.e., 60% of difference in the spread of fixed rate and floating rate [inflow] [see note]	Will pay to Somnath share in the gain on account of interest rate swap i.e., 60% of difference in spread of 1% i.e., 0.60% [outflow].

Gain on account of Interest Rate Swap:

Spread in fixed rate	[12.50 − 10.00%]	2.50%
Less: Difference in floating rate	[1% − (− 0.50%)]	1.50%
Net difference	[Maximum Gain]	1.00%
Share of Somnath in the gain	[60% of 1%]	0.60% p.a.
Share of Amal in the Gain	[40% of 1%]	0.40% p.a.

2. Effective Interest Rate

Particulars	Somnath Ltd	Amal IT Services
Expectation in Interest rate	Contraction	Increase
Interest Rate Scheme (Desired)	Floating Rate	Fixed Rate
Interest rate Less: Share in Gain	MIBOR−0.50% 0.60%	12.50% 0.40%
Effective Interest Gain	MIBOR−1.10%	12.10%

3. Interest Cost Saved

Particulars	Somnath Ltd	Amal IT Services
Share in Gain (p.a.)	0.60%	0.40%
Amount of Loan	₹100 crores	₹100 crores
Interest Savings per annum	₹60 lakhs [₹100 crores × 0.6%]	₹ 40 lakhs [₹100 crores ×0.40%]
Number of years of loan	7 years	7 years
Total Interest Savings	₹4.20 crores [7 × ₹0.60 crores]	₹2.80 crores [7 × ₹0.40 crores]

Illustration 67

Structure of a swap arrangement in the following situations and also ascertain the extent of gain

Case	Company D			Company E		
	Interest rates		Expectation on interest rate			Expectation on interest rate
	Floating	Fixed		Floating	Fixed	
1	PLR + 0.50%	12.00%	Increase	PLR + 0.50%	11.00%	Increase
2	PLR + 1.00%	11.00%	Decrease	PLR + 2.00%	12.00%	Increase
3	PLR + 1.25%	11.25%	Decrease	PLR − 0.50%	10.75%	Decrease
4	PLR − 1.50%	10.00%	Increase	PLR − 0.50%	11.50%	Decrease

PLR refers to Prime Lending Rate of a Bank i.e., Benchmark Lending Rate, which are altered time to time by the banks.

Solution:

Case	Evaluation on Interest Rates	Structure of Swap	Extent of Gain
1	⅄ Fixed rate spread= 12.00%−11.0% =1.00% ⅄ Floating Rate Spread = 0.50% − 0.50% = 0 ⅄ Difference in spread = 1.00% Possibility of Gain on Swap: Yes	E is the stronger Company (due to interest rate advantage). Company E has an advantage of 1% in Fixed Rate and no advantage in Floating Rate. Therefore, E Ltd. Should opt for Fixed Rate and D Ltd. Opt for Floating Rate with their Bankers.	Total Gain=1.00%
2	⅄ Fixed rate spread =12.00%−11.0% =1.00% ⅄ Floating Rate Spread = 2.00% − 1.00%=1% ⅄ Difference in spread = 0% Possibility of Gain on Swap: No	Swap Arrangement will not lead to any interest advantage. Therefore, no viable swap arrangement can be structured.	Total Gain=0
3	⅄ Fixed rate spread= 11.25% − 10.75% = 0.50% ⅄ Floating Rate Spread = 1.25% − (− 0.50%) =1.75% ⅄ Difference in spread =1.25% Possibility of Gain on Swap: Yes	E is the stronger company (due to interest rate advantage). Company E has an advantage of 0.50% in fixed rate and 1.75% advantage in floating rate. Therefore, E Ltd should opt for Floating Rate and D Ltd. opt for Fixed Rate with their Bankers.	Total Gain=1.25%
4	⅄ Fixed rate spread= 11.50% − 10.00% =1.50% ⅄ Floating Rate Spread =1.50% − 0.50% =1.00% ⅄ Difference in spread = 0.50% Possibility of Gain on Swap: Yes	D is the stronger company (due to interest rate advantage). Company D has an advantage of 1.50% in fixed rate and 1.00% advantage in floating rate. Therefore, D Ltd should opt for Fixed Rate and E Ltd. opt for Floating Rate with their Bankers.	Total Gain=0.50%

Illustration 68

Companies X and Y face the following interest rates:

Particulars	X	Y
U.S. Dollars (floating rate)	LIBOR +0.50%	LIBOR+1.0%
Canadian Dollar (fixed rate)	5.0%	6.5%

Particulars	Value (₹)
a. Difference in floating Rates [(LIBOR +1%) − (LIBOR+0.50%)]	0.5%
b. Difference in Fixed Rates [6.5% − 5%]	1.5%
c. Net Difference {[(a) − (b)] in absolute terms}	1.0%
d. Amount paid for arrangement of Swap Option	(0.5%)
e. Net Gain [(c) − (d)]	0.5%
f. Company X's share of gain [0.5% × 60%]	0.3%
g. Company Y's share of gain [0.5% × 40%]	0.2%

Company X	Company Y
1. Company X will borrow at Fixed Rate	1. Company Y will borrow at Floating Rate
2. Pay Interest to bankers at fixed rate (5.0%).	2. Pay Interest to bankers at floating rate (LIBOR+1.0%).
3. Will collect from Company Y interest amount differential i.e. Interest computed at Fixed Rate (5.0%) Less Interest Computed at Floating rate of (LIBOR+0.5%) =4.5% − LIBOR	3. Will pay interest amount differential to Company X i.e. Interest computed at Fixed Rate (5.0%) Less Interest Computed at Floating rate of (LIBOR+0.5%) =4.5% − LIBOR
4. Receive its share of gain from company Y = 0.3%	4. Pay to company X its share of Gain = 0.2%
5. Effective Interest Rate:2−3−4 =Fixed Rate paid by Company X − Interest Differential Received from Company Y − Share of Gain = (5.0%) − (4.5% − LIBOR) − 0.3% = LIBOR+0.2%	5. Pay commission Charges to the Financial Institution for arranging Interest Rate Swaps i.e.,0.5%
	6. Effective Interest Rate:2+3+4+5 = Floating Rate to Company Y(LIBOR+1.0%)+ Interest Differential paid to Company X (4.5% − LIBOR)+ Share of Gain paid to Company X (0.25%)+ Commission charges paid (0.5%) = LIBOR+1.0% +4.5% − LIBOR+0.2%+0.5% = 6.2%

Illustration 69

Companies PQR and DEF have been offered the following rate per annum on a $200 million five-year loan:

Company	Fixed Rate	Floating Rate
PQR	12.00%	LIBOR+0.1%
DEF	13.40%	LIBOR +0.6%

Company PQR requires a floating rate loan; Company DEF requires a fixed rate loan.

Design a swap that will net a bank acting as intermediary at 0.5% per annum and be equally attractive to both the companies.

Solution:

Particulars	Value (₹)
a. Difference in floating Rates [(LIBOR +0.1%) − (LIBOR+0.60%)]	0.5%
b. Difference in Fixed Rates [13.4% − 12%]	1.4%
c. Net Difference {[(a) − (b)] in absolute terms}	0.9%
d. Amount paid for arrangement of Swap Option	(0.5%)
e. Net Gain [(c) − (d)]	0.4%
f. Company X's share of gain [0.5% × 60%]	0.2%
g. Company Y's share of gain [0.5% × 40%]	0.2%

PQR is the strongest company (due to comparative interest advantage). PQR has an advantage of 1.40% in fixed rate and 0.5% in floating rate. Therefore, PQR enjoys a higher advantage in Fixed Rate Loans. Therefore, PQR will opt for Fixed Rate Loans with its bankers. Correspondingly DEF Ltd. will opt for Floating Rate Loans with its bankers.

Company PQR	Company DEF
1. Company PQR will borrow at Fixed Rate.	1. Company DEF will borrow at Floating Rate.
2. Pay Interest to bankers at fixed rate (12.0%).	2. Pay Interest to bankers at floating rate (LIBOR+0.6%).
3. Will collect from Company DEF interest amount differential i.e. Interest computed at Fixed Rate (12.0%) Less Interest Computed at Floating rate of (LIBOR+0.1%) =11.9% − LIBOR	3. Will pay to Company PQR interest amount differential i.e. Interest computed at Fixed Rate (12.00%) Less Interest Computed at Floating rate of (LIBOR+0.1%) =11.9% − LIBOR
4. Receive its share of gain from company DEF=0.2%	4. Pay to company PQR its share of Gain=0.2%
5. Effective Interest Rate: 2-3-4 = (12.00%)−(11.9%−LIBOR)−0.2% = LIBOR−0.1%	5. Pay commission Charges to the Financial Institution for arranging Interest Rate Swaps i.e.,0.5%
	6. Effective Interest Rate:2+3+4+5 = Floating Rate to Company DEF (LIBOR+0.6%)+ Interest Differential paid to Company PQR (11.9% − LIBOR) + Share of Gain paid to Company PQR + Commission charges paid for arranging Swaps = LIBOR+0.6% +11.9% − LIBOR+0.5%+0.2% =13.2%

Illustration 70

Company A has outstanding debt on which it currently pays fixed rate of interest at 9.5%. The company intends to refinance the debt with a floating rate interest. The best floating rate it can obtain is LIBOR + 2%. However, it does not want to pay more than LIBOR. Another Company B is looking for a loan at a fixed rate of interest to finance its exports. The best rate it can obtain is 13.5%, but it cannot afford to pay more than 12%. However, one bank has agreed to offer finance at a floating rate of LIBOR + 2%. Citi Bank is in the process of arranging an interest rate swap between these two companies.

a. With a schematic diagram, show how the swap deal can be structured.

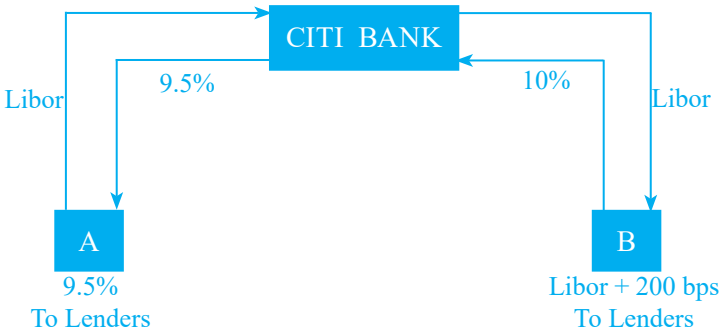
b. What are the interest savings by each company?

c. How much would Citi bank receive?

Solution:

First let us tabulate the details to find the quality of spread differential:

		Cost of Funds to Company A and B	
	Objective	Fixed rate	Floating rate
Company A	Floating	9.50% p.a.	Libor + 200bp
Company B	Fixed	13.50% p.a.	Libor + 200bp
Differential		400 bps	0bps



The differential between the two markets = 400 bps. A total of 400 bps needs to be shared between A, B and Citi bank. Since A cannot afford to pay more than Libor, it needs 200 bps benefits out of the total 400 bps (Libor + 2% - Libor). Similarly B cannot pay more than 12% as against the existing available fixed rate funding of 13.5%, it requires 150 bps benefits out of 400 bps. The balance 50 bps would be shared / Charged by the Citi bank.

The swap can therefore be structured as follows:

Firm	Paid to Bank	Received from Bank	Paid to market	Net Cost	Savings
A	Libor	9.5%	9.5%	Libor	(Libor +2%) – (Libor) = 200bps
B	10%	Libor	Libor +200bps	12%	(13.5 − 12.0) = 150bps

Company A gets floating rate funds at Libor as against Libor + 2%, thereby getting an advantage of 200 bps, Company B gets fixed rate funds at 12% as against 13.5%, thereby getting an advantage of 150 bps and finally Citi bank gets 50 bps commission.

13.4.2.2 Credit Default Swaps

⊙ **Concept of Credit Default Swap**

A credit default swap (CDS) is a financial instrument for swapping the risk of debt default. In other words, a CDS is a credit derivative contract between two counterparties under which the buyer makes periodic payments to the seller and in return receives a payoff if the underlying financial instrument defaults or experiences a similar credit event. Here the underlying financial instrument may be emerging market bonds, mortgage-backed securities, assets backed securities, corporate bonds or local government bonds.

Forms of credit default swaps had been in existence from at least the early 1990s, with early trades carried out by Bankers Trust in 1991. J.P. Morgan & Co. is widely credited with creating the modern credit default swap in 1994. In 2000, credit default swaps became largely exempt from regulation by both the U.S. Securities and Exchange Commission (SEC) and the Commodity Futures Trading Commission (CFTC). By 2007, the outstanding credit default swaps value stood at $62.2 trillion. During the financial crisis of 2008, the value of CDS was hit hard, and it dropped to $26.3 trillion by 2010 and $25.5 trillion in 2012. In mid-2010, the value of outstanding CDS was $26.3 trillion.

⊙ **Uses of Credit Default Swaps**

Credit default swaps can be used by investors for speculation, hedging as well as arbitrage.

a. Hedging

Credit default swaps are often used to manage the risk of default which arises from holding debt. A bank, for example, may hedge its risk that a borrower may default on a loan by entering into a CDS contract as

the buyer of protection. If the loan goes into default, the proceeds from the CDS contract will cancel out the losses on the underlying debt.

Another kind of hedge is against concentration risk. A bank's risk management team may advise that the bank is overly concentrated with a particular borrower or industry. The bank can lay off some of this risk by buying a CDS, because the borrower—the reference entity—is not a party to a credit default swap, entering into a CDS allows the bank to achieve its diversity objectives without impacting its loan portfolio or customer relations. Similarly, a bank selling a CDS can diversify its portfolio by gaining exposure to an industry in which the selling bank has no customer base.

Example : A pension fund owns 5-year bonds issued by C Corp. with par value of ₹10 million. To protect itself from the loss arising on the possible default of C Corp. the pension fund buys a CDS from Derivative bank in a notional amount of ₹10 million. The CDS trades at 200 basis point (2% p.a.). There may arise the following two situations. (₹ millions)

No default at all		Default after three years	
Premium paid (10×2%×5)	1	Premium paid (10×2%×3)	0.6
Bond proceeds received from C Corp. on maturity	10	Proceeds received from bank on default of C Corp. (assuming zero recovery)	10
Net proceeds (default risk avoided)	9	Net Proceeds *(default risk avoided)	9.4

*Without CDS, loss would have been ₹10 million (subject to recovery)

b. Arbitrage

Capital Structure Arbitrage is an example of an arbitrage strategy that utilizes CDS transactions. This technique relies on the fact that a company's stock price and its CDS spread should exhibit negative correlation; i.e., if the outlook for a company improves then its share price should go up and its CDS spread should tighten and vice-versa. Techniques reliant on this are known as capital structure arbitrage because they exploit market inefficiencies between different parts of the same company's capital structure; i.e., mis-pricings between a company's debt and equity. An arbitrageur will attempt to exploit the spread between a company's CDS and its equity in certain situations. For example, if a company has announced some bad news and its share price has dropped by 25%, but its CDS spread has remained unchanged, then an investor might expect the CDS spread to increase relative to the share price. Therefore, a basic strategy would be to go long on the CDS spread (by buying CDS protection). This technique would benefit in the event of the CDS spread widening relative to the equity price.

Interest Rate Derivatives – Forward Rate Agreement, Interest Rate Futures and Options, Caps, Floors and Collars

13.5

Concept of Interest Rate Derivatives

Interest Rate Derivative (IRD) is a financial derivative contract whose value is derived from one or more interest rates, prices of interest rate instruments, or interest rate indices. Interest rate derivatives are often used as hedges by institutional investors, banks, companies, and individuals to protect themselves against changes in market interest rates, but they can also be used to increase or refine the holder's risk profile or to speculate on rate moves. In practice, Interest Rate Derivatives are used to limit interest rate risks. By means of Interest Rate Derivatives, one can get protection against rising or falling interest rates.

Types of Interest Rate Derivatives

Following are various types of interest rate derivatives:

a. **Forward Rate Agreement (FRA):** An FRA is an agreement between participants (normally the Bank and a Customer) to pay or receive the difference (called settlement money) between an agreed fixed rate (FRA rate) and the interest rate prevailing on stipulated future date (the fixing date) based on a notional amount for an agreed period (the contract period). Thus, FRA allows participants to make a known interest payment at a later date and receive in return an unknown interest payment. In that way, a participant whose business will involve borrowing at a future date can lock in a fixed payment and receive a random payment that offsets the unknown interest payment it will make on its loan.

b. **Interest Rate Futures:** An Interest Rate Futures contract is "an agreement to buy or sell a debt instrument at a specified future date at a price that is fixed today." At NSE the underlying security for Interest Rate Futures is either Government Bond or T-Bill. Exchange traded Interest Rate Futures on NSE are standardized contracts based on 6-year, 10 year and 13-year Government of India Security (NBF II) and 91-day Government of India Treasury Bill (91DTB). All futures contracts available for trading on NSE are cash settled.

c. **Interest Rate Options:** Interest Rate Option (IRO) is an option contract whose value is based on interest rates or interest rate instruments. At NSE, currently, IRO contracts are available on Government of India securities.

d. **Interest Rate Swaps:** An interest rate swap is a financial contract between the two parties who want to exchange the interest payments or receipts in the same currency on assets or liabilities to a different basis. There is no exchange of principal amount here. In other words, it is an exchange of interest payment for a specific maturity on an agreed upon notional amount.

e. **Interest Rate Caps:** An interest rate cap is a type of interest rate derivative in which the buyer receives payments at the end of each period in which the interest rate exceeds the agreed strike price (the maximum interest rate). An example of a cap would be an agreement to receive a payment for each month the LIBOR rate exceeds 2.5%. An Interest Rate Cap (Cap) is an interest rate risk management tool that provides the borrower with protection against adverse rate movements above an agreed "Strike" or maximum interest rate.

f. **Interest Rate Floor:** An interest rate floor is a derivative contract in which the buyer receives payments at the end of each period in which the interest rate is below the agreed strike price. An example of a cap would be an agreement to receive a payment for each month the LIBOR rate falls below 1.5%. An Interest Rate Floor (Floor) is an interest rate risk management tool that provides the borrower with protection against adverse rate movements below an agreed "Strike" or minimum interest rate.

g. **Interest Rate Collars:** An interest rate collar is an instrument that combines both a cap and a floor. The cap component of the instrument gives the investor protection against rising rates by guaranteeing that the investor will never pay above a pre-agreed rate. The floor component of the collar allows the investor to take advantage of the falling interest rates until the interest rate hits a predetermined rate known as floor rate. Thus, an Interest Rate Collar (Collar) is an interest rate risk management tool that effectively creates a band within which the borrower's variable interest rate will fluctuate, by combining an Interest Rate Cap with an Interest Rate Floor.

Some of the above derivatives are discussed in detail in the following section. For Interest Rate Swaps, please refer to Section 13.4 of this Module.

13.5.1 Forward Rate Agreement

a. Concept and Mechanism

A Forward Rate Agreement (FRA) is a contract between the two parties, (normally between a banker and its customer or independent party), in which one party (the banker) gives the other (customer) a guaranteed future rate of interest to cover a specified sum of money over a specified period of time in the future. For example, two parties agree that a 6 percent per annum rate of interest will apply to one year deposit in six months' time. If the actual rate of interest proves to be different from 6 percent, then one party will pay and other receives the difference between the two sets of interest cash flows.

In an FRA, no actual lending or borrowing is done. It only fixes the rate of interest for a futures transaction. At the time of maturity, when the customer actually needs funds, then he has to borrow the funds at the prevailing rate of interest from the market. If the market rate of interest is higher than the FRA interest then the banker will have to pay to the other party (customer) the difference in the interest rate. However, if market interest is lesser than the FRA rate then the customer will have to pay the difference to the banker. This transaction is known as purchase of FRA from the bank.

Sometimes, a customer (depositor) may also make a FRA contract with the bank for his deposits for seeking a guaranteed rate of interest on his deposits. If the market rate on his deposit turns out to be lower than that guaranteed interest rate in the FRA, the bank will compensate him for the difference, i.e., FRA rate minus market interest.

In this way, purchase of FRA protects the customer against a rise in interest in case of borrowing from the bank. Similarly, sale of FRA will protect the customer from deposits point of view. The bank charges different rates of interest for borrowing and lending, and the spread between these two constitutes bank's profit margin. As a result, no other fee is chargeable for FRA contracts.

b. Determination of Settlement amount

Final settlement amounts owed by the parties to an FRA are determined by the formula:

$$\text{Payment} = \text{Notional Amount} \times \frac{\text{Reference Rate} - \text{Fixed}}{\text{Rate 1} + \text{Reference Rate} \times \alpha} \times \alpha$$

Where, α is the day count function

c. Settlement

Situation	Course of action
Forward Rate > LIBOR	Buyer has to pay the decrease in interest cost i.e., FR - LIBOR
Forward Rate < LIBOR	Seller has to pay the increased interest cost i.e., LIBOR - FR

Note: The principal amount is "notional" since though it determines the amount of differential payment to be settled between the parties, actual exchange of principal never takes place.

Consider the following Example on settlement process.

d. Example on FRA

Let two banks A and B enter into a Forward Rate Agreement containing the following clauses: (a) A forward rate of 10% on a Eurodollar deposit with 6 months maturity. (b) A $5 Million notional principal and (c) Settlement in 2 months. Show the settlement process.

Solution:

(a) The above agreement is termed as 2×8 FRA - Since it fixes the interest rate for a deposit to be placed after 2 months and maturing 8 months after the date the contract is negotiated.

(b) Settlement:

(i) If the 6-month LIBOR is 12% on the settlement date, the seller would owe the buyer - 2% (difference between 12% and 10%) interest on $5 million for 6 months amounting to $50,000.

(ii) But the interest on a Eurodollar deposit is paid on maturity (at the end of the term of deposit) whereas FRAs are settled on the contract maturity date (which would correspond to the date the underlying hypothetical deposit would be placed). Therefore, to make the cash payment on the FRA equivalent to the extra interest that would have been earned on a Eurodollar deposit paying 12%, the difference of $50,000 in interest costs calculated above is discounted back 6 months using the actual 6-month LIBOR of 6%.

(iii) Hence, on contract maturity date the buyer would receive $50000 ÷ [l+0.06(180/360)] = $48,543.69

Consider the following illustrations.

Illustration 71

Consider that a bank sells a 3 × 6 FRA worth $3,00,00,000. The agreed rate with the buyer is 5.5 %. There are actually 92 days in the three-month FRA period. Assume that three months from today the settlement rate is 4.875%. Determine how much the FRA is worth and whom pays who i.e. whether the buyer pays the seller or seller pays the buyer. Had the settlement rate been 6.125%, what is the answer?

Solution:

A seller of a FRA would benefit if the settlement rate is lower than the agreed rate. Since the settlement rate is less than the agreement rate, the buyer pays the seller the absolute value of the FRA. The payoff of the FRA is:

$$\text{Payoff} = \text{Notional Amount} \times \frac{\text{Reference Rate} - \text{Fixed Rate}}{1 + \text{Reference Rate} \times \alpha} \times \alpha \text{ (}\alpha\text{ is the day count function)}$$

$$= 3,00,00,000 \times \frac{(0.04875 - 0.055) \times 92/360}{1+(0.04875 \times 92/360)}$$

$$= 47,326.39$$

Hence, Payoff is $ 47,326.39

Had the settlement rate been 6.125%, since the settlement rate is greater than the agreement rate, the seller pays the buyer the absolute value of the FRA. The absolute value of the FRA is:

$$= 3,00,00,000 \times \frac{(0.06125 - 0.055) \times 92/360}{1+(0.06125 \times 92/360)}$$

= 47,178.20

Hence, Payoff $ 47,178.20

Illustration 72

MNC rolls over a $25 million loan priced at LIBOR on a three-month basis. The company feels that interest rates are rising and that rates will be higher at the next roll-over date in three months. Suppose the current LIBOR is 5.4375%. Explain how MNC can use FRA at 6% offered by a bank to reduce its interest rate risk on this loan. In three months, if interest rates have risen to 6.25%, how much will MNC receive/pay on its FRA? Assume the three month period as 90 days.

Solution:

MNC can use 3×6 FRA, if it expects that the rates would be higher at the next roll-over of three months, starling three months from today. In other words MNC would buy 3×6 FRA @ 6%, clearly with a view that higher rate would prevail on the settlement date i.e. 3 months from now.

Now if on the settlement date, the rate is 6.25%, then MNC's decision to buy 3×6 FRA has been proved right and it would receive the present value of the interest differentials on the loan amount i.e. it would receive:

$$\text{Payoff} = \text{National Amount} \times \frac{\text{Reference Rate} - \text{Fixed Rate}}{1 + \text{Reference Rate} \times \alpha} \times \alpha \text{ (}\alpha\text{ is the day count function)}$$

$$= \$2,50,00,000 \times \frac{(0.0625 - 0.0600) \times 92/360}{1+ (0.06125 \times 90/360)}$$

= $15,385

13.5.2 Interest Rate Futures

a. Concept and features of Interest Rate Futures

As mentioned earlier, Interest rate futures is standardized interest rate derivative contract traded on a stock exchange to buy or sell an interest-bearing instrument at a specified future date, at a price determined at the time of the contract. The contracts are exchange traded.

Following are the features of Interest Rate Futures:

(i) These are exchange traded cash settled contracts.

(ii) The contract size is kept at the minimum for wider participation.

(iii) Transparency is the key to these contracts. Settlement is done at clean price.

(iv) Contracts available across yields/benchmarks/maturities.

(v) There is centralized clearing supported by guaranteed settlement.

(vi) They provide easier and cheaper access to rates trading.

b. Uses of Interest Rate Futures

Following are the purposes form which Interest Rate Futures are used:

(i) Hedging

(ii) Managing the Duration of a Portfolio

(iii) Yield Locking

(iv) Using Calendar Spread for Speculation

(v) Arbitrage

(vi) Directional Trading

Some of these uses are described below with appropriate examples.

- **Hedging:** All types of investors are exposed to interest rate risk. Interest rate exposure can be hedged by taking an opposite position in IRF to offset a loss (gain) in underlying exposure with potential gain (loss) in the IRF.

  Consider the following example.

  Suppose, an investor holds debt-oriented mutual fund. He expects that yield will rise and NAV will decrease. However, Investor does not wish to redeem MF units. Here, the investor will short IRF to hedge, as illustrated below:

On Trade Date (say on 22th April, 2021):	
Investment Holding	Debt Oriented Mutual Fund 10,000 units @ NAV ₹13.30
Strategy Sell	610GS2031 lot of 2,000 bonds i.e., 6.1% Govt. Securities maturing in 2031 with lot size 2,000 bonds
Future price of 6.10% GS 2031 (May contract)	₹ 104.20
On Expiry Date (26th May, 2021):	
NAV of MF	₹13.15
Final Settlement Price of 6.10% GS 2031 (May contract)	₹ 103.50
Loss on underlying MF	10,000 × (13.30 − 13.15) = (₹ 1500)
Profit In IRF	2,000 × (104.20 − 103.50) = ₹ 1400
Net Profit / (Loss)	(₹ 100)

  Thus, he successfully avoids the loss on mutual funds.

- **Calendar Spread:** A Calendar Spread, also known as an Inter-delivery Spread, is the simultaneous purchase of one delivery month of a given futures contract and the sale of another delivery month of the same underlying on the same exchange.

  The mechanism of a calendar spread is explained in an example below:

	First leg – 3rd March 2021	Second Leg – 31st March 2021
Security	6.10 % GS 2031	6.10 % GS 2031
Strategy	Sell Spread i.e., Buy near month and Sell mid-month Buy April contract @105.00 Sell May Contract @105.10	Square off the position Sell April contract @104.20 Buy May contract @104.25
Profit / Loss (INR)	0.10	-0.05
Total Profit / Loss (INR)	0.05 per bond. ₹100 per lot	

- **Directional Trading:** As there is an inverse relationship between interest rate movement and underlying bond prices, the futures price also likely to move vis-a-vis the underlying bond prices. If an investor has a strong view that interest rates will increase in the near future and wants to reap benefit from the rise in interest rates, he can take a short position in IRF contracts and benefit from the falling futures prices.

  Consider the following example:

  Suppose, an investor expects yields to rise or that bond prices to fall. In order to reap the benefits, he will IRFs on the expectation of fall in prices. Suppose the investor sells the futures contract when the yield is 9.01% & buys it back when yield increases by 9 bps, i.e.,9.10%. During the period, the future price changes from 104.45 to 103.90. Lot size of 8.57% GOI Securities maturing in 2031 is 2,000. The investor sells 10 lots with applicable margin at 2.5%. The investor, in this case, will earn a profit of ₹11,000 as illustrated below:

Underlying Bond	8.57% GOI 2031
Futures Contract	30.06.2021
Trade Date	04.06.2021
Future Price (INR)	104.45
Yield	9.01%
Position	Short Position i.e., Sell Futures
Lot Size	2,000
No. of Lot	10
Total Value (INR)	(2,000 × 10 × 104.45) = 20,89,000
Margin (2.5% approx.) (INR)	52,225
Trade Date	12.06.2021
Future Price (INR)	103.9
Yield	9.10%
Position Square of positions	Long Position (to Square Off): Buy Futures
Total Value (INR)	(2,000 × 10 × 103.90) = 20,78,000
Profit/Loss (INR)	11,000

13.5.3 Interest Rate Options

Interest Rate Options are a derivative financial instrument that allows an investor to gain from the changes in the interest rates. These are connected to interest-bearing financial products, such as treasury notes. Moreover, these options trade on exchanges, such as CME Group, and are also available OTC (over the counter). An interest rate option works similarly to stock options, allowing buyers to speculate on the direction of the interest rate movement. However, unlike stock options, interest rate options depend on the actual rates. Moreover, Federal Reserve or any other authority can influence the interest rates. Thus, it is very important that investors in interest rate options have a good knowledge of the macroeconomic factors that can impact the interest rates.

There are two types of interest rate options – call and put. A call option gives the investor the right (not obligation) to gain from a rise in the interest rate. The holder of a call option will profit if the interest rate is above the strike rate at the time of the expiry. However, the holder will only make a profit if the interest rate at expiry is high enough to cover the premium cost as well.

In contrast, a put interest rate option gives the buyer the right (not obligation) to gain from the drop in the interest rates. The holder makes a profit if the interest rate drops below the strike rate and is enough to cover the premium cost as well. Such options are profitable when they are in the money.

The mechanism of Interest Rate Options can be explained with the help of the following example.

Suppose, in USA, an investor wants to speculate on rising interest rates, they could buy a call option on the 30-year Treasury with a strike price $60 and an expiration date of August 31st. The premium for the call option is $1.50 per contract. In the options market, the $1.50 is multiplied by 100 (lot size) so that the cost for one contract would be $150, and two call option contracts would cost $300.

If yields rise by August 31st, and the option is worth $68 at expiry, the investor would earn the difference of $8, or $800 based on the multiplier of 100. If the investor had originally bought one contract, the net profit would be $650 or $800 minus the $150 premium paid to enter into the call option.

Conversely, if yields were lower on August 31st, and the call option was now worth $55, the option would expire worthless, and the investor would lose the $150 premium paid for the one contract.

In India, Interest Rate Options are traded at NSE and BSE. At NSE, currently, Interest rate Options are based on underlying G-Sec bonds 5.77% 2030 Bond, 5.79% 2030 Bond, 5.85 % 2030 Bond, 6.10 % 2031 Bond & 6.67 % 2035 Bond. The unit of trading is ₹ 2 lakh face value of G-Sec, corresponding to 2,000 units. The order quotation is the premium quoted as the price of G-Sec and the tick size is ₹ 0.0025.

13.5.4 Interest Rate Caps

a. Concept of Interest Rate Cap

An interest rate cap is an agreement between two parties in which one party, for an up-front premium, agrees to compensate the other party if a designated interest rate, called the reference rate, is different from a predetermined level. In other words, an interest rate cap is an option to fix a ceiling or maximum short term interest rate payment. The contract is written such that the buyer of the cap will receive a cash payment equal to the difference between the actual market interest rate and the cap strike rate on the notional principal, if the market rate rises above the strike rate. Usually, caps are designed to provide insurance against the rate of interest on a floating-rate loan going above a certain level. This level is known as the cap rate.

b. Features of Interest Rate Caps

(a) The buyer of an Interest Rate Cap pays premium to the seller for the right to receive the difference in interest cost (on notional principal) when a specified index of market interest rates rises above a stipulated "cap rate".

(b) The buyer has no obligation or liability if interest rates fall below the specified cap rate.

(c) Thus, a cap resembles an option which represents a right rather than an obligation to the buyer.

(d) Interest rate caps cover periods ranging from 1-10 years with interest rate reset and payments dates most commonly set either 3 or 6 months apart.

c. Constituents

(a) Notional Principal amount

(b) Interest Rate Index (say, LIBOR)

(c) A Cap rate which is equivalent to strike or, exercise price on an option and

(d) Period of agreement, including payment dates and interest rate reset dates.

d. Valuation of Interest Rate Cap

Amount of payment on settlement: $[(N) \times \text{Max}(0, r - rc) \times (dt/360)]$

Where, N = Notional principal amount; r = Index rate; rc = cap rate; dt = time gap between interest rate reset date and payment date (in days)

e. Settlement

If the specified market index is above the cap rate, the seller pays the buyer the difference in interest cost on the next payment date.

13.5.5 Interest Rate Floors

a. Concept of Interest Rate Floor

An interest rate floor guarantees the buyer of the floor option a minimum interest rate to be received on a specified notional amount for a specified period or series of periods. In other words, the floor writer pays the floor buyer when the reference rate falls below the contract rate, called floor rate. So, a floor places a lower limit on the interest rate that will be charged.

If a lending firm fears that interest rates may fall in future, it may wish to purchase a floor so that it can receive a minimum return on invested funds. If the actual market rate of interest falls even below the floor ace, the holder of the floor will receive from the writer of the floor a cash payment equal to the difference between the actual reference rate (say, LIBOR) and the floor rate.

b. Features of Interest Rate Floors

(a) The buyer of an Interest Rate Floor pays premium to the seller for the right to receive the difference in interest cost (on notional principal) when a specified index of market interest rates falls below a stipulated "floor rate".

(b) The buyer has no obligation or liability if interest rates rise above the specified floor rate.

(c) Thus, a floor resembles an option which represents a right rather than an obligation to the buyer.

(d) Interest rate floors cover periods ranging from 1-10 years with interest rate reset and payments dates most commonly set either 3 or 6 months apart.

c. Constituents

(a) Notional Principal amount

(b) Interest Rate Index (say, LIBOR)

(c) A Floor rate which is equivalent to strike or, exercise price on an option and

(d) Period of agreement, including payment dates and interest rate reset dates.

d. Valuation of Interest Rate Floors

Amount of payment on settlement: [(N) × Max (0, rf - r) × (dt/360)]

Where, N = Notional principal amount; r = Index rate; rf = floor rate; dt = time gap between interest rate reset date and payment date (in days)

e. Settlement

If the specified market index is below the floor rate, the seller pays the buyer the difference in interest cost on the next payment date.

13.5.6 Interest Rate Collars

An interest rate collar is a combination of an interest rate cap and an interest rate floor in which the buyer buys a cap and simultaneously sells a floor. So, collars specify both the upper and lower limits for the rate that will be charged. Collar can be constructed from two separate transaction (one for cap another for floor) or they can be combined into a single transaction. Since the collar has the effect of locking both the high side and the lower side interest rate, it is also called locking into a band. Further, if the collar is created by two separate contracts, so as a purchaser one will pay the premium, and as a seller the premium will be received. When the two premiums are equal, the position is often referred to as a zero-premium collar.

The basic objective of constructing a collar is to retain some of the benefits of declining rates while paying if the interest rate falls below a particular limit. Let us consider an example. Suppose that a firm holds a fixed rate assets which are yielding 11 percent. These assets are financed through floating rate liabilities tied to the LIBOR, assuming current rate at 9 percent. Suppose that the firm wants to cap the-cost at 10.5 percent (buying a cap at 10.5 percent) then it has to pay upfront premium, assuming 0.5 percent p.a. If the firm feels that this premium is too high to pay, but, as it happens, the firm finds that it can sell a prime (a prime rate or prime lending rate is an interest rate used by banks, usually the interest rate at which banks lend to customers with good credit) floor with a floor rate at 7 percent for a premium at 0.5 percent p.a. From the firm's perspective, its annual costs are now bounded between 7 percent to 9.5 percent. It means that when the prime rate rises above 9.5 percent, the dealer pays the firm the difference. If prime rate falls below 7 percent, the firm pays the difference to the dealer.

Consider the following illustrations on interest rate caps, floors and collars.

Illustration 73

Amit Company has borrowed $200 million on floating basis for 3 years. The interest rates reset every year. The spread over LIBOR is 25 bps. The company buys a 3 year cap on a 1-year LIBOR with a strike rate of 9% and having a face value of $200 million. The cap carries a premium of 2% of face value or $4 million. Current 1 Year LIBOR is 9%. If the LIBOR at the end of 1, 2 and 3 years are 9.5%, 8.5% and 10%, what is the cash flow from cap each year? Amortize premium equally over three years.

Solution:

The strike rate of the cap is Libor which is currently 9%. Since the spread over Libor is 25 bps, the interest rate applicable on the borrowing would be 9.75%, 8.75% & 10.25% respectively for the three years. Thus the interest payable in amount terms over three years would be: $1,95,00,000, $1,75,00,000 and $2,05,00,000 respectively. Now, the premium paid for buying this cap is $ 4 million. As given in the problem equal amortization would involve $13,33,333 each year. The seller of the cap would part with the difference whenever Libor is above the strike price. Therefore we can construct the cash flow table as follows:

(Amount in $)

Time	Cash Flow : Loan	Amortization of premium	Cash Flow from Cap	Total
0	+20,00,00,000	-	-	+20,00,00,000
1	−1,95,00,000	−13,33,333	+10,00,000	−1,98,33,333
2	−1,75,00,000	−13,33,333	-	−1,88,33,333
3	−2,05,00,000	−13,33,333	+20,00,000	−1,98,33,333
3	−20,00,00,000	-	-	−20,00,00,000

Illustration 74

A fund manager Mr. Adittya deposited $200 million on floating basis for 3 years, which pay LIBOR + 50 bps. The interest rates are reset every year. The company buys a 3 year floor on a 1-year LIBOR with a strike rate of 8% and having a face value of $200 million. The floor carries a premium of 1.5% of face value or $3 million. Current 1 year LIBOR is 8.60%. If the LIBOR at the end of 1, 2 and 3 years are 7.5%, 9% and 7%, what is the cash flow from floor each year? Amortize premium Equally over three years.

Solution:

The strike rate of the floor is Libor which is currently 8.6% The interest rate applicable on the deposit would be Libor + 50 bps i.e. 50 bps over 7.5%, 9% & 7% respectively for the three years. Thus the interest payable in amount terms over three years would be: $1,60,00,000, $1,90,00,000 and $1,50,00,000 respectively. Now, the premium paid for buying this floor is $ 3 million. As given in the problem equal amortization would amortization would involve $10,00,000 each year. The seller of the floor would part with the difference whenever the Libor is below the strike price of 8%. Therefore we can construct the cash flow table as follows:

Time	Cash Flow : Deposit	Amortization of Premium	Cash Flow from Floor	Total
0	−20,00,00,000	-	-	−20,00,00,000
1	+1,60,00,000	−10,00,000	+10,00,000	+1,60,00,000
2	+1,90,00,000	−10,00,000	-	+1,80,00,000
3	+1,50,00,000	−10,00,000	+20,00,000	+1,60,00,000
3	+20,00,00,000	-	-	+20,00,00,000

Illustration 75

DY has purchased ₹400 million cap (i.e., call options on interest rates) of 9% at a premium of 0.65% of face value. ₹400 million floor (i.e., put options on interest rates) of 4% is also available at premium of 0.69% of face value.

(a) If interest rates rise to 10%, what is the amount received by DY? What are the net savings after deducting the premium?

(b) If DY also purchases a floor, what are the net savings if interest rates rise to 11%? What are the net savings if interest rates fall to 3%?

(c) If, instead, DY sells (writes) the floor, what are the net savings if interest rates rise to 11%? What if they fall to 3%?

(d) What amount of floors should it sell in order to compensate for its purchases of caps, given the above premium?

Solution:

(a) Premium for purchasing the cap = 0.65% × ₹400 million = ₹26,00,000. If interest rates rise to 10 percent, cap purchasers receive ₹400 million × 0.01 = ₹40,00,000. The net savings is ₹14,00,000.

(b) If DY also purchases the floor: Premium = 0.0069 × ₹400 million = ₹27,60,000, and the total premium = ₹27,60,000 + ₹26,00,000 = ₹53,60,000.

If interest rates rise to 11 percent, cap purchasers receive 0.02 × ₹400 million = ₹80,00,000 and the net savings = ₹80,00,000 – ₹53,60,000 = ₹26,40,000.

If interest rates fall to 3 percent, floor purchaser receive 0.01 × ₹400 million = ₹40,00,000 and the net savings = ₹40,00,000 – ₹53,60,000 = – ₹13,60,000.

(c) If DY sells the floor, it receives net ₹27,60,000 (-) the cost of the cap of ₹26,00,000 = + ₹1,60,000.

If interest rates rise to 11 percent, cap purchasers receive 0.02 × ₹400 million = ₹80,00,000. The net the savings = ₹80,00,000 + ₹1,60,000 = ₹81,60,000.

If interest rates fall to 3 percent, floor purchasers receive 0.01 × ₹400 million = ₹40,00,000. The net savings to DY = – ₹40,00,000 + 1,60,000 = – ₹38,40,000

(d) DY. Needs to sell: X × 0.0069 = ₹26,00,000, or X = ₹37,68,11,594 worth of 4 percent floors.

Solved Case Studies

Heading of Risks - Futures Rate Available Vs. Future rate not Available

1. Fashion Ltd. manufactures cruiser bikes for export to Americana and Europe. It requires a special type alloy called "Fecal" made up of Iron, Aluminum and Cope. Fecal is sold at ₹230 per kg in the spot market. If Fashion Ltd. has a requirement of 6 tonnes in 6 months time, and the 6-Months Future Contract rate is ₹2.42 Lakhs per tonne. Carrying cost is 5% p.a. if the interest rate is 10%, should the Company opt for Futures Contract?

Case A: If the Company does opt for Futures Contract for buying 6 Tonnes of Fecal, what will be the effect if –

(a) Spot Rate at the end of 6 months is ₹2,55,000 per tonne?

(b) Spot Rate at the end of 6 months is ₹2,35,000 per tonne?

Has the Company gained or lost? If the Company has lost, is it proper to conclude that Futures Contract has failed to save the company from loss, and therefore need not be resorted to?

Case B: what will be the course of action and effect of such action in the above two cases, if -

(a) There is no Futures Market for Fecal;

(b) Hedge ratio for Fecal with the Metal Index is 0.9 i.e. Beta of Fecal with Metal Index is 0.90 (i.e. beta for change in values)

(c) Each Metal index contract is equivalent to 5000 kgs of Fecal.

(d) 6-Months' Metal Index Future is 4800 points [Assume futures contract are divisible]

If in Case A, Fashion Ltd. wants to cash in on an arbitrage opportunity, what should it do?

Solution:

1. Computation of Theoretical Forward Price [TFP_x]

$FP_x = S_x \times e^{(r+c)\times t}$

Where,

S_x = Current Spot Price = ₹230 per kg or ₹2,30,000 per tonne

r = Rate of Interest per annum = 10% p.a. or 0.10

c = Carrying Cost (rate per annum) = 5% p.a. or 0.05

t = Period of Futures contract in Years = 6 Months or 0.50 Years

$TFP_x = ₹2,30,000 \times e^{(0.10+0.05)\times 0.50}$

$= ₹2,30,000 \times e^{0.15 \times 0.50}$

$= ₹2,30,000 \times e^{0.075}$

$= ₹2,30,000 \times 1.0779$

$= ₹2,47,917$

2. Evaluation of Futures Contract Proposal

- Theoretical Futures price ₹2,47,917 is greater than Actual Futures Price ₹2,42,000
- Therefore, the Company should go in for futures for buying 6 Tonnes of Fecal
- Theoretically the Company stands to gain ₹5,917 per tonne based on theoretical futures Price
- Company can freeze its loss (based on current spot price of ₹2.30 Lakhs per tonne) to ₹10,000 per tonne.

3. Effect of Futures Contract Proposal – Based on Actual Spot rate 6-Months Later

Particulars	Case A	Case B
Spot Rate (6-Months later) is (per tonne)	₹2.55 Lakhs	₹2.35 Lakhs
Actual Futures price is (per tonne)	₹2.42 Lakhs	₹2.42 Lakhs
6-Month's Future price vs. Spot Rate [s_1]	AFP is lower	AFP is higher
Based on Actual Spot Rate on the date of exercise		
(i.e. 6 Months later), buying 6 tonnes at ₹2.42 Lakhs per tonne	Gain of ₹13,000 per tonne.	Loss of ₹7,000 per tonne.

Conclusion:

- Futures contract does not eliminate loss. It only eliminates uncertainty associated with price. It is only a guarantee that the contractee will not gain or lose beyond a particular level (level determined by the Future price) with reference to the current spot price.
- As a hedging tool, it freezes (fixes) the price and thereby mitigates the risk associated with price. The maximum gain or loss is known the day on which futures contract is entered into. One need not wait for the actual delivery or exercise day to know the rate.
- Therefore, it is inappropriate to conclude that Futures Contract should not be resorted to since it has failed to save the company from loss.

4. No future Rate Available

(a) Basis and suggested course of Action

- Since Fecal is not traded in the Futures Market, Fashion Ltd. can resort to Cross Hedge i.e. entering into a Futures Contract in a related index/commodity (whose prices move in tandem with Fecal)
- Since the Metal Index moves in tandem with the price of Fecal, Fashion Ltd. should enter into a Futures Contract in Metal index opposite to its position in Fecal's Cash Market i.e. it required 6 tonnes of Fecal six months hence (Going Long), therefore, it should sell 6 Months future Contract for Metal Index (Going Short)
- Course of Action: Sell Metal Index Futures. Buy Fecal Stock in Cash Market (to be executed six Months hence)

(b) Activity Flow

Activity	Time	Description
Contract	Now	Enter into 6 Month's Futures Contract for Selling 10.80 Metal Index futures
Settle Futures Contract	6-Months Later	Settle 6-Month's Future Metal Index liability by pocketing (gain) or paying (loss) the price difference. Gain (₹) = No. of Contracts × No. of Fecal Units per Contract × Gain in Metal Index Points Loss (₹) = No. of Contracts × No. of Fecal Units per Contract × Loss in Metal Index Points
Buy	6-Months Later	Buy Six Tonnes at prevailing spot price [Prevailing Spot Price = Spot Price at the beginning of Futures contract ± Gain/Loss in settlement of Metal Index Futures]

Working note: Contract Determination

$$\text{Number of Metal Index futures to be sold} = \text{Hedge Ratio} \times \frac{\text{Units of Spot Position requiring hedging}}{\text{No. of Units Underlying one Futures Contract}}$$

$$= \text{Hedge Ratio [Beta of changes in Price of Fecal w.r.t. metal Index]} \times \frac{\text{Quality of Fecal required by Fashion}}{\text{Quantity of fecal equivalent of one Futures Contract of Metal Index}}$$

$$= 0.90 \times (6 \text{ Tonnes} \div 0.50 \text{ Tonne}) = 0.90 \times 12 = 10.80 \text{ Futures Contracts}$$

(c) Cash Flow

Price in Spot Market 6-Months later is ₹2.55 Lakhs

Particulars	Value
Value per Kg six months later [₹2,55,000÷1,000 Kgs]	₹255
Less: Value per Kg at the beginning	₹230
Appreciation / (Depreciation) in price per Kg of Fecal	₹25
Hedge Ratio (i.e.Beta Value of movement in Fecal w.r.t to Metal Index Futures)	0.90

Appreciation in Metal Index [per metal index futures [Appreciation in Fecal price ÷ Hedge Ratio] = 25÷0.90 = 27.778 points i.e. Metal Index would have appreciated by 27.778 points to 4,827.778 points (4,800 + 27.778)	27.778 Points
Gain on Settlement of Metal Index Futures [No. of Contract × No. of Fecal Units per Contract × Gain in Metal Index points] = 10.80 × 500 kgs × 27.778	
[This is the Cash Inflow for Fashion Ltd]	₹1,50,000
Cash Outflow	
=> For purchase of 6 Tonnes of Fecal ₹2.55 Lakhs per tonne × 6 tonnes = ₹15,30,000 = Spot Price at the Beginning + Gain on Settlement of Metal Index Futures = ₹2,30,000 × 6 Tonnes + ₹1,50,000 = ₹13,80,000 + ₹1,50,000	₹15,30,000
Net Outflow for Fashion Ltd. = ₹15,30,000 – ₹1,50,000	₹13,80,000

Price in Spot Market 6-Months later is ₹2.35 Lakhs

Particulars	Value
Value per Kg six months later [₹2,35,000 ÷ 1,000 Kgs]	₹235
Less: Value per Kg at the beginning	₹230
Appreciation / (Depreciation) in price per kg of Fecal	₹5
Hedge Ratio (i.e. Beta Value of movement in Fecal w.r.t to Metal Index Futures)	0.90
Appreciation in Metal Index [per metal index futures] = Appreciation in Fecal Price ÷ Hedge Ratio = 5 ÷ 0.90 = 5.556 points i.e. Metal Index would have appreciated by 5.556 points to 4805.556 points (4800 + 5.556)	5.556 points
Gain on Settlement of Metal Index Futures [No. of Contracts × No. of Fecal Units per Contract × Gain in Metal Index Points] = 10.80 × 500 kgs. × ₹5.556 [This is the Cash Inflow for Fashion Ltd.]	₹30,000
Cash Outflow	
=>For purchase of 6 Tonnes of Fecal ₹2.35 Lakhs per tonne × 6 Tonnes = ₹14,10,000 = Spot Price at the Beginning + Gain on Settlement of Metal Index Futures = ₹2,30,000 × 6 Tonnes + ₹30,000 = ₹13,80,000 + ₹30,000	₹14,10,000
Net Outflow for Fashion Ltd. = ₹14,10,000 – ₹30,000	₹13,80,000

5. Arbitrage Opportunity

- **Position:** Theoretical Futures Price (₹2,47,917)≠Actual Futures Price (₹2,42,000)
- **AFP vs. TFP:** To benefit from the opportunity, Fashion Ltd. should buy Future and Sell Spot.
- Profit: = Sale Value (Spot Price) − Purchase Cost (Present Value of Future Price)

  = [₹2,30,000 × 6 Tonnes] − [₹2,42,000 per Tonnes÷e^{rt}]

  = ₹13,80,000 − [₹14,52,000 ÷ $e^{(0.10+0.05)\times 0.5}$]

  =₹13,80,00 − [₹14,52,000 ÷ $e^{0.15\times 0.5}$]

  =₹13,80,000 − [₹14,52,000 ÷ $e^{0.075}$]

  =₹13,80,000 − [₹14,52,000 ÷ 1.07788]

  = ₹13,80,000 − ₹13,47,089

  = ₹32,911.

2. Soumo has ₹3,00,000 to invest in the Capital Market. He Considers stock of Kraft Components Ltd, an auto mobile industry ancillary unit, to be a safe bet, KCL is currently traded at ₹200. Industry analyst say opine that KCL will either remain at ₹190 or go upto ₹250 in 6- months time, considering the performance of the industry. Soumo views this as an opportunity and has decided to invest ₹3,00,000 to buy shares of KCL and earn a maximum of upto 25% which is more than the risk free rate.

   His actuarial friend, Rakesh, also has ₹3,00,000 to invest. However, he considers Soumo's proposition to be bit risky, having some knowledge on options, Rakesh intends to buy calls and invest at Risk Free Rate of 12%. 6-Months option carries an Exercise Price of ₹220.

   What should be the price of the call, for Rakesh's proposition to yield the same result 6- months later (i.e. a minimum net wealth of ₹3,00,000)? How many calls should Rakesh buy?

   Who would be better off at the end of 6-months, if the actual spot price is ₹180, ₹250 and ₹300?

   Solution:

   1. Basic Data

Particulars	₹
Current Stock Price (SP_0)	200
Exercise Price (EP)	220
Expected Future Spot Price on Expiry Date	
⅄ Future Price 1 [FP_1]	190
⅄ Future Price 2 [FP_2]	250

   2. Computation of Option Delta:

Particulars	FP_1	FP_2
Future Spot Price	190	250
Position on Expiry Date(in comparison with Exercise Price of ₹ 220)	Out of Money	In the Money
Action on expiry date	Lapse	Exercise
Value of Option on Expiry [Future Spot Price Less Exercise Price]	₹ 0	₹ 30 [250-220]

   Option Delta = Change in Value of Option ÷ Change in Future Spot Price

   = (₹30 – ₹0) ÷ (₹250 – ₹190) = ₹30 ÷ ₹60 = 0.50

   3. Computation of Amount to be invested at Risk Free Rate:

   = Present Value of Lower Band of Future Spot Price i.e. FP_1

   = Present Value of ₹190 discounted at 12% Continuous Compounding for a 6-Month Period

   = ₹190 × e^{-rt} = ₹190 ÷ e^{rt}

   = ₹190 ÷ $e^{0.12\times0.5}$

   = ₹190 ÷ $e^{0.06}$

   = ₹190 ÷ 1.0618 = ₹178.94

   4. Value of Call [C]

   = Option Delta×[Current Stock Price Less Amount to be invested at Risk Free Rate]= 0.50×(₹200–178.94)

   = 0.50 × ₹21.06 = ₹10.53

5. Value of Put [P] (Under Put Call Parity):

→ Value of Call + Present Value of Exercise Price = Current Spot Price + Value of Put

→ $C + EP \times e^{-rt} = SP_0 + P$

→ ₹10.53 + (₹220 ÷ 1.0618) = ₹200 + P

→ P = ₹10.53 + ₹207.20 – ₹200 = ₹17.73

6. No. of Calls to be Bought by Rakesh

= (1 ÷ Options Delta) per share of KCL

= 1 / 0.50 = 2 per share of KCL or 5 Calls for every 3 Shares of KCL

7. No. of Shares that can be bought = ₹3,00,000 ÷ ₹200 per share (CMP) = 1,500 shares

8. Position 6 - Months Later

(a) Soumo

Particulars	Case A	Case B	Case C
Closing Net Worth = Actual Stock Price after 6 Months	₹180 × 1500 Shares = ₹2,70,000	₹250 × 1500 Shares = ₹3,75,000	₹300 × 1500 Shares = ₹4,50,000
Opening Net Worth= Purchase Price of Stock/ Initial Investment	₹200 × 1500 Shares = ₹3,00,000	₹200 × 1500 Shares = ₹3,00,000	₹200 × 1500 Shares = ₹3,00,000
Change	(₹30,000)	₹75,000	₹1,50,000
% Change	(10%) [(30)÷300]	25% [75÷300]	50% [150÷300]
Inference	Erosion in Wealth	Increase in Wealth	Increase in Wealth

(b) Rakesh

Outflow per set of 5 Calls on KCL and Investment of ₹178.94 in Risk Free per Share for 3 shares.

Particulars		Value
Outflow towards Purchase of Calls Outflow	5 Call's × ₹10.53 per Call	₹52.65
Towards Investment	3 Shares of KCL × ₹178.94	₹536.82
Total Investment per set of 5 Calls and Risk Free Investment		₹589.47
Total Number of Portfolio Sets invested	₹3,00,000 ÷ ₹589.47	509 Sets
Total No. of Calls	509 Sets × 5 Calls per Set	2545 Calls
Total amount invested in Risk Free Rate	509 Sets × ₹536.82	₹2,73,241

Particulars	Case A	Case B	Case B
Actual Closing Price per Share	₹180	₹250	₹300
Exercise Price	₹220	₹220	₹220
Position	Out of Money	In the Money	In the Money
Action	Lapse	Exercise	Exercise

Value of Call before Expiry	₹0	₹30 [₹250 – ₹220]	₹80 [₹300 – ₹220]
No. of Calls	2545	2545	2545
Total Value of Calls on Expiry [6–Months later] [A]	₹ NIL [2545 × ₹0]	₹76,350 [2545 × ₹30]	₹2,03,600 [2545 × ₹80]
Maturity Value of Investment [Investment ₹2,73,241 × $e^{0.12\times0.5}$] [B]	₹2,90,127 [2,73,241 × 1.0618]	₹2,90,127 [2,73,241 × 1.0618]	₹2,90,127 [2,73,241 × 1.0618]
Closing Net Worth [A+B]	₹2,90,127	₹3,66,477	₹4,93,727
Opening Investment	₹3,00,000	₹3,00,000	₹3,00,000
Change	₹(9,873)	₹66,477	₹1,93,727
%Change	(3.291)% (9,873 ÷ 3,00,000)	22.16% [66,477 ÷ 3,00,000]	64.58% [1,93,727 ÷ 3,00,000]
Inference[Ignoring Time Value of Money]	Decrease in wealth	Increase in Wealth	Increase in Wealth

Conclusion:

- Rakesh will be better off when actual market price is either ₹250 or ₹300.
- Risk is neutralized in case of Rakesh by going in for the Options.

Exercise

Theoretical Questions

Multiple Choice Questions

1. A buyer of forward contract will make profit if
   A. Future price is lower than the forward price
   B. Future price is higher than the forward price
   C. Future price is equal to the forward price
   D. Both (A) and (C) of the above
2. Which of the following is/are underlying instrument(s) in a Forward Rate Agreement?
   A. Interest rate
   B. Exchange rate
   C. Inflation rate
   D. Both (a) and (c) of the above
3. The market in which the futures price is greater than the spot price is referred to as
   A. Basis
   B. Contango
   C. Backwardation
   D. Reverse Cash and carry arbitrage market
4. Buying and selling call or put option with the same strike price but different expiration dates is called
   A. Long hedge
   B. Short hedge
   C. Horizontal option spread
   D. None of the above.
5. Maintenance margins deposited by an investor in a futures contract is
   A. Greater than or equal to the initial margin
   B. Less than or equal to the initial margin
   C. Greater than the initial margin
   D. Less than the initial margin
6. Backwardation occurs when
   A. Current spot price = futures price
   B. Current spot price < futures
   C. Futures price < current spot price
   D. Futures price > current spot price
7. American options are those
   A. Options which are traded on New York Stock Exchange
   B. That can be exercised at any time during a specified period
   C. That can be exercised only at the specified period
   D. That can be exercised even after the specified period

8. The writer of the option is also known as a
   A. Buyer of the option
   B. Holder of the option
   C. Seller of the option
   D. Mediator of the option
9. Covered Call Writing means
   A. Buying a stock and a put option and writing a call option on the asset already owned
   B. Buying a call option and stock and writing a put option
   C. Buying a call option and writing a put option
   D. Selling a call option and purchasing a stock
10. Plain vanilla interest rate swaps involved
   A. Fixed to fixed rate swap
   B. Fixed to floating rate swap
   C. Floating to floating rate swap
   D. Currency swap

Answer:

1	2	3	4	5	6	7	8	9	10
B	A	B	C	D	C	B	C	D	B

State True or False

1. The derivatives market helps to transfer risks.
2. A forward contract is a standardized contract.
3. A credit derivative is a contract whose value depends on the creditworthiness or a credit event experienced by the entity referenced in the contract.
4. Basis is defined as the Spot price minus the futures price.
5. Intrinsic value is the amount by which the price of an option exceeds its intrinsic value.
6. Option which gives the holder the right to sell an asset, but not an obligation to sell is called a call option.
7. A diagonal spread can be created by using similar options with different strike prices and also different time to expire.
8. Delta of a Stock Option is the ratio of the change in the price of the stock option to the change in the price of the underlying stock.
9. An interest rate cap is a type of interest rate derivative in which the buyer receives payments at the end of each period in which the interest rate exceeds the agreed strike price (the maximum interest rate).
10. A CDS in which the buyer does not own the underlying debt is referred to as a naked credit default swap.

Answer:

1	2	3	4	5	6	7	8	9	10
True	False	True	False	False	False	True	True	True	True

Fill in the Blanks

1. Derivatives are mostly _____ market instruments.
2. In a_____, the holders get the full amount of loan and interest accrued only at the maturity of the bond.
3. _____ is an option contract whose value is based on interest rates or interest rate instruments.
4. Longer the time to maturity, higher the period of uncertainty, and hence _____ the option premium.
5. An interest rate _____is an instrument that combines both a cap and a floor.
6. A _____ spread is a non-directional options strategy that limits both gains and losses while seeking to profit from either low or high volatility.
7. Option premium is paid by the _____to the _____ of the option.
8. Hedge Ratio = _____ ÷ Underlying asset position.
9. _____ essentially means that at the end of the trading session (day), all outstanding contracts are repriced at the settlement price of that session (daily closing price).
10. The financial forward and futures contracts are priced using the _____ Model.

Answer:

1	secondary	2	zero-coupon bond
3	Interest Rate Option	4	higher
5	collar	6	condor
7	buyer, seller	8	Futures Position
9	Marking to market	10	Cost of Carry

Short Essay Type Questions

1. Discuss the benefits of financial derivatives.
2. Discuss, in brief, the four basic financial derivatives.
3. What do you mean by Forward Contract? Discuss its features.
4. In the context of Futures Contract, discuss the feature 'Standardization'.
5. Write a Short Note on: Types of Option Contracts.
6. Write a Short Note on: Interest Rate Collars.
7. Explain 'in-the-money', at-the-money' and 'out-of-the-money' options.
8. What is the difference between Intrinsic Value and Time Value of an option contract?
9. Write a Short Note on: Types of Credit Default Swap.
10. How can Credit Default Swaps be used for hedging? Explain with the help of one example.

Practical Problems

Multiple Choice Questions

1. An investor writes a three-month put on the stock of an oil company at an exercise price of ₹275 per share at a premium of ₹34. If the expiration date price is ₹280, calculate the gain/loss of put writer.

   A. ₹5

   B. (-) ₹5

   C. ₹34

   D. None of the above

2. An investor buys 100 shares of a sugar mill at ₹210 per share and at the same time writes a September 250 call at a premium of ₹20 per share. If the expiration date price is ₹280, calculate the net gain/loss.

   A. ₹20

   B. ₹40

   C. ₹60

   D. None of the above

3. If the share of BA Ltd. (F. V. ₹10) quotes ₹920 on NSE, and the 3 months futures price quotes at ₹950, and the borrowing rate is given as 8% and the expected annual dividend yield is 15% p.a. payable before expiry, then the price of 3-month BA Ltd. futures would be

   A. ₹948.40

   B. ₹939.90

   C. ₹938.50

   D. ₹936.90

4. The stock of ABC Ltd. sells for ₹210. The present value of exercise price and the value of call option are ₹217.40 and ₹9.60 respectively. What is the value of put option?

   A. ₹16.50

   B. ₹22.00

   C. ₹17.00

   D. ₹18.00

5. In June 2005, a six month Call on Ritz Ltd.'s stock with an exercise price of ₹25 sold for ₹5. The stock price was ₹20. The risk- free interest rate was 5% per annum. How much would you be willing to pay for a Put Option on Ritz Ltd.'s stock with same maturity and exercise price? [Given: PVIF (5%, 1/2 year) = 0.9756]

   A. ₹6.39

   B. ₹9.39

   C. ₹12.39

   D. None of (A), (B), (C).

6. A call option at a strike price of ₹ 200 is selling at a premium of ₹ 24. At what share price on maturity will it break-even for the buyer of the option?

   A. ₹ 200

   B. ₹ 176

   C. ₹ 224

   D. ₹ 248

7. An investor is bullish about X Ltd. which trades in the spot market at ₹ 1,150. He buys two call option contracts with three months (one contract is 100 shares) with a strike price of ₹ 1,195 at a premium of ₹ 35 per share. Three months later, the share is selling at ₹ 1,240. Net profit/loss of the investor on the position will be

   A. ₹ 1,000

   B. ₹ 16,000

   C. ₹ 11,000

   D. ₹ 2,000

8. M buys a call option contract for a premium of ₹ 200. The exercise price is ₹ 25 and the current market price of the share is ₹ 22. If the share price after three months reaches ₹ 30, what is the profit made by M on exercising the option? A contract is for 100 shares. Ignore transaction charges.

   A. ₹ 200

   B. ₹ 300

   C. ₹ 100

   D. ₹ 600

9. Presently, a company's share price is ₹ 120. After 6 months, the price will be either ₹ 150 with a probability of 0.8 or ₹ 110 with a probability of 0.2. A call option exists with an exercise price of ₹ 130. What will be the expected value of call option at maturity date?

   A. ₹ 20

   B. ₹ 16

   C. ₹ 12

   D. ₹ 10

10. A stock is currently selling at ₹ 270. The call option to buy the stock at ₹ 265 costs ₹ 12. What is the Time Value of the option ?

    A. ₹ 5

    B. ₹ 17

    C. ₹ 7

    D. None of (A), (B) or (C)

11. The spot Value of Nifty is 4430. An investor bought a one month Nifty 4410 call option for a premium of ₹ 12. The option is:

    A. In the money

    B. At the money

    C. Out of the money

    D. Insufficient data

12. You are given the following information of a stock:

    Strike Price ₹ 400

    Current stock price ₹ 370

    Risk free rate of interest 5%

    Theoretical minimum price of a European 6 months' put option after six months is

    A. ₹ 9.37

    B. ₹ 20.12

    C. ₹ 30.76

    D. ₹ 20.63

13. A wants to hedge its portfolio of shares worth ₹ 150 million using the Index futures. The contract size is 100 times the index. The index is currently quoted at 7500. The beta of the portfolio is 0.9. Consider the beta of the index as 1. The number of contracts to be traded is

    A. 18000

    B. 180

    C. 22

    D. 200

14. A company's share is currently trading at ₹ 240. After 6 months, the price will be either ₹ 250 with probability of 0.80 or ₹ 220 with probability 0.20. A European call option exists with an exercise price of ₹ 230. The expected value of call option at maturity date will be

    A. ₹ 10

    B. ₹ 16

    C. ₹ 4

    D. ₹ 14

15 An option's theoretical value increases by 1.75 if the interest rate is decreased by 1%.Then, 1.75 is

    A. The rho of a put option

    B. The rho of a call option

    C. The theta of call option

    D. The theta of a put option

16. Which of the following is not an assumption of Black-Scholes Model?

    A. The risk-free rate of interest is known

    B. Options can be exercised only at expiration

    C. Dividend is paid on the shares

    D. No imperfection exists in writing an option

17. When the spot price decreases, the value of a call option

    A. is equal to its premium

    B. decreases

    C. increases

    D. does not change

18 Buying a call and put with the same expiry date, on the same stock with a different strike price is a

A. Strangle

B. Strap

C. Straddle

D. Strip

19. A stock is currently sells at ₹ 350. The put option to sell the stock sells at ₹ 380 with a premium of ₹ 20. The time value of option will be

A. ₹ 10

B. ₹ -10

C. ₹ 20

D. ₹ 0

20. An investor bought 2,000 shares of X Ltd. for ₹ 90 per share. The initial margin is 50%. The maintenance margin is 40%. If the stock price decreases to ₹ 70 per share. The additional funds put by the investors to his margin account is –

A. ₹ 20,000

B. ₹ 20,500

C. ₹ 21,000

D. ₹ 22,000

21. What should be the price of call, if value of a put ₹ 5, strike price ₹ 100, rate of interest 6% p.a. , time period -2 months?

A. ₹ 4

B. ₹ 5

C. ₹ 6

D. ₹ 7

22. An investor purchases a July Call Option of X Ltd. with a strike price of ₹ 100 for a premium of ₹ 7. Till what level the investor will not realize his profit.

A. ₹ 105

B. ₹ 107

C. ₹ 110

D. ₹ 115

23. In a put-call parity, the pay-offs of buying stock can be replicated by:

A. Buying a call and buying a put option

B. Buying a call and writing a put option

C. Writing a call and buying a put option

D. Writing a call and writing a put option

24. A stock is currently sells at ₹ 350. The put option to sell the stock sells at ₹ 380 with a premium of ₹ 20. The time value of option will be

    A. ₹ 10

    B. ₹ 10

    C. ₹ 20

    D. 0

25. The spot value of NIFTY is 6430. An investor bought a two month NIFTY for 6410 call option for a premium of ₹ 24. The option is

    A. In-the Money

    B. At-the Money

    C. Out-of the Money

    D. Insufficient Data

26. Shares of C Ltd. is traded at ₹ 1,150. An investor is bullish about the market. He buys two one month call option contracts (one contract is 100 shares) on C Ltd. with a strike price of ₹ 1,195 at a premium of ₹ 35 per share. Three months later, if the share is selling at ₹ 1240 what will be net profit/loss of the investor on the position?

    A. ₹ 1000

    B. ₹ 1200

    C. ₹ 1500

    D. ₹ 2000

27. A stock index currently stands at 7000. The risk free interest rate is 8% p.a. continuously compounded and the dividend yield on the index is 4% p.a. What should be the futures price for a four month contract? [Given e(.08-.04)4/12 = 1.013423]

    A. 7093.96

    B. 7097.34

    C. 7098.68

    D. 7099.25

28. A 6-month forward contract on a non-dividend paying stock when the stock price is ₹ 60 and the riskfree interest rate (with continuous compounding) is 12% p.a. What is the forward price? [Given e0.06 = 1.0618]

    A. ₹ 61.86

    B. ₹ 62.23

    C. ₹ 64.23

    D. ₹ 65.27

29. If you sell a call option on a share with a strike price of ₹ 375, market price of ₹ 360, and a premium of ₹ 21.What is the maximum loss on expiry of this position?

    A. ₹ 354

    B. Unlimited

    C. ₹ 396

    D. None of these

Answer:

1	2	3	4	5	6	7	8	9	10
C	C	D	C	B	C	D	B	B	C
11	12	13	14	15	16	17	18	19	20
A	B	B	B	A	C	B	A	D	A
21	22	23	24	25	26	27	28	29	
C	B	B	D	A	D	A	A	B	

Comprehensive Numerical Problems

1. On Aug. 2, Mr. Tandon buys 5 contracts of December Reliance features at 840. Each contract covers 50 shares. Initial margin was set at ₹2,400 per contract while maintenance margin was fixed at ₹2,000 per contract.

   Daily settlement prices are as follows:

   Aug. 2 818

   Aug. 3 866

   Aug. 4 830

   Aug. 5 846

   Mr. Tandon meet all margin calls. Whenever he is allowed to withdraw money from the Margin Account, he withdraws half the maximum amount allowed.

   Compute for each day: (i) Margin call; (ii) Profit & (Loss) on the contracts; (iii) The balance in the Account at the end of the day.

   [Answer: (i) 5,500, Nil, 3,000, Nil; (ii) (-) 5,500, 12,000, (-) 9,000, 4,000; (iii) 12,000, 18,000, 12,000, 14,000]

2. The settlement price of JUNE NIFTY Futures contract on a particular day was 4585. The minimum trading lot on Nifty futures is 100. The initial margin is 8% and the maintenance margin is 6%. The index closed at the following levels on the next five days:

Day	Settlement Price (₹)
1	4,690
2	4,760
3	4,550
4	4,480
5	4,570

   Required:

   (i) Calculate the Mark to Market Cash Flows and daily closing balances in the account of (A) an investor who has gone long at 4585; (B) an investor who has gone short at 4585.

   (ii) Calculate the net profit/(loss) on each of the contracts.

   [Answer: (i) (A) Cash flows: + 10,500, + 7000. - 27,000. - 7,000, + 9000 Closing Balance: 47180, 54180, 33180, 366680, 0 (B) Cash Flows: - 10,500, 7,000, + 21,000, + 7,000, - 9,000 Closing Balance: 36680, 29680, 50680, 57680, 48680 (ii) Long: Loss of ₹ 1500, Short: Profit of ₹1500]

3. MUMBAI LTD. is an Indian company, they are in the process of raising a US dollar loan and are negotiating the rates with City Bank. The company has been offered a fixed rate of 7% p.a. with a provision that should they opt for a floating rate, the interest rate is likely to be linked to the Bench mark rate of 60 basis points over the 10-year US T - Bill Rate, with interest re fixation on a three monthly basis. The expectations of Mumbai Ltd are that the dollar interest rates with fall, and are inclined to have a flexible-mechanisms built into their interest rates. On enquiry they find that they could go for a swap arrangement with CHENNA1 INDIA LTD. who have been offered a floating rate of 120 basis points over 10-year US T - Bill Rale, as against a fixed rate of 8.20%. Describe the swap on the assumption that the swap differential is shared between Mumbai Ltd. and Chennai India Ltd. in the proportion of 2: 1.

4. Shares of M Ltd. are currently trading at ₹190. At the end of three months, the stock price is expected to be ₹125 or ₹225 with respective probabilities 1/3 and 2/3. The 3-months' European call option on M Ltd. is available with an exercise price of ₹175. The risk-free rate of interest is 6% per annum continuously compounded.

   (i) Find out the value of a 3-month European Call under the Binomial Model (Delta Method).

   (ii) Calculate the value of the put option under Put-Call Parity.

   (iii) If an investor wants to buy 100 shares, how many call options should be transacted in for a complete hedge? Present workings to prove that the risk is covered.

   (iv) What is the expected value of the option and also of the stock price at the end of three months?

   [Answer: (i) ₹33.43; (ii) ₹15.82; (iii) 200; (iv) ₹33.33 and ₹191.67]

5. The following information is given:

Current Stock Price	₹ 190
Strike Price	₹ 210
Price of 6 months' European Put Option	₹ 10
Risk free interest rate p.a.	5%

   (i) Calculate the theoretical minimum price of the put option at the end of 6 months.

   (ii) Show the arbitrage process step by step and find out the gain if

      (a) the price on the expiration day is ₹ 200

      (b) the price on the expiration day is ₹ 220.

   [Answer: (i) ₹14.813]

6. The following quotes are available for 3-months options in respect of a share of P Ltd. which is currently traded at ₹ 310.

   Strike Price ₹ 300

   Call option ₹ 30

   Put option ₹ 20

   An investor devises a strategy of buying a call and selling the share and a put option.

   Risk free interest rate is 10% per annum.

   Using Put-call parity theory

   (i) Find out profit/loss of the investor.

   (ii) What would be the position if the strategy adopted is selling a call and buying the put and the share? ($e^{0.025}$ = 1. 0253; $e^{0.25}$ = 1. 2840)

   [Answer: (i) ₹7.40]

7. Y, a British firm with a US subsidiary, seeks to refinance some of its existing British pound debt to include floating rate obligations. The best floating rate it can obtain in London is LIBOR + 2.0%. Its current debts are as follows:

   US$ 10 million owed to CT Bank at 9.5% (fixed annually); and

   £ 5 million owed to MD Bank at 9.5% (fixed) annually.

   HRS Company wishes to finance exports to Britain with £3 million of pound denominated fixed rate debt for six months. HRS is unable to obtain a fixed interest rate in London for less than 13.5% interest because of its lack of credit history in the UK. However, Lloyds Bank is willing to extend a floating rate British pound loan at LIBOR + 2%. HRS, however, cannot afford to pay more than 12%.

   Assume that Y is in a strong bargaining position and can negotiate the best deal possible, but HRS will not pay over 12%. Assume further that transaction costs are 0.5% and exchange rates are stable.

   Can Y and HRS help each another by an interest rate swap? If so, how? Compute the amount of gains for Y, HRS and the Swap Dealer.

   Illustrate the effective post-swap interest rates of each party with a diagram. What are the effective interest rates for each party over the six months period of the swap?

8. A share is currently priced at ₹600. It is known that at the end of one month, it will be either ₹570 or ₹630. The risk-free interest rate is 8% per annum with continuous compounding. Find the value of a one-month European call option with a strike price of ₹592 with the help of a Binomial Model. (Given that $e^{0.007} = 1.00702$)

   [Answer: ₹21.522]

9. Companies X and Y want to raise US$ 50 million each. They have been offered the following rates per annum:

Company	Fixed	Floating
X	7.5%	LIBOR + 25 bps
Y	8.45%	LIBOR + 37 bps

   Bank B, on a commission of 0.2% (fully borne by Y) is arranging an interest rate swap between X and Y. X wants a floating rate and Y wants a fixed rate. Work out the payables and receivables on the swap (in %), given that the benefits (after commission) are shared between X and Y in the ratio 60: 40. What will be the effective rate of interest payable by X and Y their respective gains (in %) due to the swap? How many dollars does each save per annum due to the swap?

10. Name the most appropriate combined trading strategy on the stock of PQ Ltd. in the following independent cases. (You may present only columns I and II in your answer books.)

Sl. No.	Strategy	Action		Expiry Date	Strike Price
		Buy	Sell		
I.		One Call One Put		30th June 30th June	215 215
II.			Two Calls One Put	20th June 20th June	220 220

III.			One Call Two Puts	20th June 20th June	230 230
IV.		One Call One Put		20th June 20th June	215 220

[Answer: I. Long Straddle; II. Strap; III. Strip; IV. Strangle]

Unsolved Case Study

Three companies, Alpha, Beta and Gamma required $100 million each for next five years. The following are the requirement and the costs of borrowings faced by them in different markets:

Company	Requirement	PLR	LIBOR	Fixed $
Alpha	PLR based $ funds	PLR + 0.30%	LIBOR + 0.50%	3.35%
Beta	LIBOR based $ funds	PLR + 0.05%	LIBOR + 0.30%	3.25%
Gamma	Fixed $ funds	PLR + 0.05%	LIBOR + 0.15%	3.10%

Alpha, Beta and Gamma, not being satisfied with the costs of borrowing at the markets of their choice, have come together to reduce their interest burden. They have approach you as an expert in this field.

Arrange a swap between these three parties in such a way that the benefit of swap is equally divided among the three parties. What is the effective cost of borrowing to each party, after the swap?

[Answer: Effective Cost: Alpha PLR + 0.25%; Beta LIBOR +0.25% and Gamma 3.05%]

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2. Hopkin; Fundamentals of Risk Management; IRM
3. Allen; Financial Risk Management a Practitioners Guide to Managing Market and Credit Risk; John Wiley
4. Hull; Risk Management and financial Institutions; Wiley