Subject: Financial Derivatives (4539292)

MBA SEM 03
Module 01

INTRODUCTION TO RISK MANAGEMENT

❖ Introduction

- The term "derivative" encompasses any financial instrument, the value of which is derived from the price of some underlying asset, index or rate.
- Originally based on commodities, the range and usage of these instruments have increased dramatically to the extent that they now cover a wide range of financial products (e.g. equities and bonds), money rates (e.g. interest and exchange rates), indices (e.g. equity and commodity indices) as well as "soft" commodities (e.g. coffee, sugar, cocoa, wheat, barley), precious and base metals, electricity, gas, oil, weather and other energy products.
- Whether transacted on a regulated exchange or on any other form of multilateral trading platform or bilaterally over-the-counter (that is, off-exchange), derivatives today are increasingly being used - and used successfully - by growing numbers of corporates, financial institutions, building societies, insurance companies, commodity groups, fund managers and other organizations.
- Whether the purpose of trading is to hedge against future adverse price movements in respect of underlying assets and/or portfolios, manage interest rate or exchange rate risks, or take positions with a view to improving profits, derivatives are and will continue to play an important and internationally recognized role in the world's trading and financial systems.

❖ Risk Management of Financial Derivatives

- In general terms, risk can be defined as anything that can impede an organization from achieving its strategic objectives. It encompasses not only some of the more predictable threats or hazards that an organization may face, but also the failure to maximize opportunity or address the uncertainty of results not being as expected - and is endemic in all forms of commercial or trading activity.
- In order to address risk in an efficient and effective manner, the organization should:
    - identify, on a continuing basis, all the risks relating to its activities, including derivatives trading activities;
    - determine its appetite for risk based on the above identification of risks, i.e. which risks it is prepared to accept and which risks it is not prepared to accept;
    - develop effective and well-understood policies for defining the context, scope and objectives for managing risk;
    - develop specific responsibilities for implementing those policies;
    - establish procedures for measuring, managing, mitigating and reporting on risk across the organization on an ongoing basis, particularly market risk, credit risk, operational risk and legal risk.

Upside Risk

A short forward position taken without an offsetting long physical position in the underlying commodity is said to have upside risk. This means the trader is speculating that the price of the commodity will decline.

Downside Risk

A long forward position taken without an offsetting short physical position in the underlying commodity is said to have downside risk. This means the trader is speculating that the price of the commodity will increase.

Commodity Price Risk

- If we look at the legal definition of a commodity, it is defined as 'a tangible item that may be bought or sold; something produced for commerce'.
- Therefore, commodities are considered to be marketable goods or wares, such as raw or partially processed materials, farm products, or even jewellery. Intangibles, such as human labour, services, or marketing & advertising, are typically not considered to be commodities.

- Commodity price risk is the financial risk on an entity's financial performance/profitability upon fluctuations in the prices of commodities that are out of the control of the entity since they are primarily driven by external market forces.

A fall in commodity prices can:

- Decrease sales revenue for producers, potentially decreasing the value of the organization, and/or lead to change in business strategy
- Reduce or eliminate the viability of production — mining and primary producers may alter production levels in response to lower prices

- Decrease input costs for businesses consuming such commodities, thus potentially increasing profitability, which in turn can lead to an increase in value of the business

A rise in commodity prices can:

- Increase sales revenue for producers if demand is not impacted by the price increase. This in turn can lead to an increase in the value of the business.
- Increase competition as producers increase supply to benefit from price increases and/or new entrants seek to take advantage of higher prices
- Reduce profitability for businesses consuming such commodities (if the business is unable to pass on the cost increases in full), potentially reducing the value of the organization.

Interest Rate Risk

- Interest rate risk is the risk to earnings or capital arising from movements in interest rates.
- The economic (capital) perspective focuses on the value of the bank in today's interest rate environment and the sensitivity of that value to changes in interest rates.
- Interest rate risk arises from differences between the timing of rate changes and the timing of cash flows (repricing risk).

❖ Approaches to Risk Management

- Typically, a dealer or active position- taker=s determination of the credit risk add-on will take one of two approaches: (1) transaction level or (2) portfolio level. These approaches are described below:

1) Transaction-Level Approach

- The transaction-level approach computes either peak or average potential credit exposure.
- Peak exposure is measured as the largest historical price movement or a statistically remote outcome such as a two- or three-standard-deviation price move.
- It can be derived from a series of possible outcomes, each with a probability of occurrence.
- The mean of these probability-weighted outcomes is the average exposure. Peak exposure reflects a more conservative assessment of potential credit risk; bank management should be prepared to justify the use of average exposure in calculating the credit risk add-on.
- The transaction-level approach treats derivatives individually and presumes the total exposure in the portfolio to be the sum of the potential exposures for each transaction.

2) Portfolio Approach

- Because the transaction-level approach ignores portfolio offsets or the probability that all transactions will not be at the peak or average exposure at the same time, it overstates the risk in the aggregate portfolio. Therefore, some banks use the portfolio approach to measure potential credit exposure.
- The portfolio approach uses simulation modeling to calculate exposures through time for each counterparty.
- For example, the master agreement may specify that a default on any one transaction is considered a default on all transactions by the counterparty.
- Accordingly, when netting is allowed, the expected exposure (close-out) amount is the net of all positive and negative replacement costs with each counterparty.

INTRODUCTION TO DERIVATIVES

❖ Introduction

- The term “Derivative” indicates that it has no independent value, i.e., its value is entirely derived from the value of the underlying asset. The underlying asset can be securities, commodities, bullion currency, livestock or anything else.
- In other words, derivative means forward, futures, option or other hybrid contract of predetermined fixed duration, linked for the purpose of contract fulfilment to the value of a specified real or financial asset or to an index of securities.
- The Securities Contracts (Regulation) Act 1956 defines “derivative” as under: “Derivative” includes:

1. Security derived from a debt instrument, share, loan whether secured or unsecured, risk instrument or contract for differences or any other form of security.
2. A contract which derives its value from the prices, or index of prices of underlying securities.

The above definition conveys that:

1. The derivatives are financial products.
2. Derivative is derived from another financial instrument/contract called the underlying.
   In the case of Nifty futures, Nifty index is the underlying. A derivative derives its value from the underlying assets.
3. Accounting Standard SFAS 133 defines a derivative as, 'a derivative instrument financial derivative or other contract with all three of the following characteristics:
   i. It has (1) one or more underlying, and (2) one or more notional amount or payments provisions or both. Those terms determine the amount of the settlement or settlements.
   ii. It requires no initial net investment or an initial net investment that is smaller than would be required for other types of contract that would be expected to have a similar response to changes in market factors
   iii. Its terms require or permit net settlement. It can be readily settled net by means outside the contract or it provides for delivery of an asset that puts the recipients in a position not substantially different from net settlement.

- The term "financial derivative" relates with a variety of financial instruments which include stocks, bonds, treasury bills, interest rate, foreign currencies and other hybrid securities.
- Financial derivatives include futures, forwards, options, swaps, etc.
- Futures contracts are the most important form of derivatives, which are in existence long before the term 'derivative' was coined.
- Financial derivatives can also be derived from a combination of cash market instruments or other financial derivative instruments.
- In fact, most of the financial derivatives are not revolutionary new instruments rather they are merely combinations of older generation derivatives and/or standard cash market instruments.

- In brief, the term financial market derivative can be defined as a treasury or capital market instrument which is derived from, or bears a close relation to a cash instrument or another derivative instrument.
- Hence, financial derivatives are financial instruments whose prices are derived from the prices of other financial instruments.

❖ **Spot Market**

- Spot markets are direct markets for primary assets, such as foreign exchange or equity. The assets are traded immediately at the time of the transaction.
- Spot trading is the most original form of trading, but it has some disadvantages.
- The timing is not flexible, traders have to deal with the physical delivery of the traded assets (such as commodities) and the interest rate spot market is affected by the counterparty default risk.
- For these reasons, derivative markets have become more important than spot markets in some cases.

❖ **Derivatives Market**

- Derivatives can either be exchange-traded or traded over the counter (OTC).
- Exchange refers to the formally established stock exchange wherein securities are traded and they have a defined set of rules for the participants.
- Whereas OTC is a dealer-oriented market of securities, which is an unorganized market where trading happens by way of phone, emails, etc.
- Derivative traded on the exchange are standardized and regulated.
- On the other hand, OTC derivative constitutes a greater proportion of derivatives contracts, but it carries higher counterpart risk and is unregulated.
- These financial instruments help in making a profit by simply betting on the future value of the underlying asset.

❖ Difference between Cash and Derivative Market:

- In cash market, we can purchase even one share whereas in case of futures and options the minimum lots are fixed
- In cash market tangible assets are traded whereas in derivatives contracts based on tangible or intangible assets are traded.
- Cash market is used for investment. Derivatives are used for hedging, arbitrage or speculation.
- In case of cash market, a customer must open a trading and demat account whereas for futures a customer must open a future trading account with a derivative broker.
- In case of cash market, the entire amount is put upfront whereas in case of futures only the margin money needs to be put up.
- When an individual buys shares, he becomes part owner of the company whereas the same does not happen in case of a futures contract.
- In case of cash market, the owner of shares is entitled to the dividends whereas the derivative holder is not entitled to dividends.

❖ Participants in the Derivative Market

The participants in the derivative markets can be segregated into three categories namely:

1) Hedgers

- These are traders who wish to protect themselves from the risk or uncertainty involved in price movement.
- They try to hedge their position by entering into an exact opposite trade and pass the risk to those who are interested to bear the same.
- By doing this they try to get rid of the uncertainty associated with the price.
- For example, you have 1000 shares of XYZ Ltd. and the CMP is Rs 50.
- You are planning to hold the stocks for 6-9 months and you expect a good upside.
- However, in the short term, you feel that the stock might see a correction but you do not want to liquidate your position today as you are expecting a good upside in the near term.
- For example, you can enter into an options contract (a part of the derivative strategy) by paying a small price or premium and reduce your losses.
- Moreover, it would help you benefit whether or not the price falls. This is how you can hedge your risk and transfer it to someone who is willing to take the risk.

2) Speculators

- They are extremely high-risk seekers who anticipate future price movement in the hope of making large and quick gains.
- The motive here is to take maximum advantage of the price fluctuations.
- They play a very key role in the market by absorbing excess risk and also provide much-needed liquidity in the market when normal investors don't participate.

3) Arbitrageurs

- Arbitrage is a low-risk trade which involves buying of securities in one market and simultaneous selling it in another market.
- This happens when same securities are trading at different prices in two different markets.
- For instance, say the cash market price of a share is Rs 100 and it is trading at Rs 110 per share on the futures market.
- An arbitrageur observes the same and bought 50 shares @ Rs 100 per share in the cash market and simultaneously sells 50 shares @Rs 110 per share, thus gaining Rs 10 per share.

❖ Derivative Instruments

The most popularly used derivatives contracts are Forwards, Futures, Options and Swaps, which we shall discuss in detail later. Here we take a brief look at various derivatives contracts that have come to be used.

1. 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.
- The rupee-dollar exchange rates is a big forward contract market in India with banks, financial institutions, corporate and exporters being the market participants.

2. 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.
- Futures often are settled in cash or cash equivalents, rather than requiring physical delivery of the underlying asset.
- Parties to a Futures contract may buy or write options on futures.

3. 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.
- Calls give the buyer the right but not the obligation to buy a given quantity of the underlying asset, at a given price on or before a given future date.
- Puts give the buyer the right, but not the obligation to sell a given quantity of the underlying asset at a given price on or before a given date.

4. 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.

- There is a recent trend for swap dealers to mark to market the swap to reduce the risk of counterparty default.
- The two commonly used swaps are:
    i. **Interest Rate Swaps**: These entails swapping only the interest related cash flows between the parties in the same currency.
    ii. **Currency Swaps**: These entail swapping both principal and interest between the parties, with the cash flows in one direction being in a different currency than those in the opposite direction. Swaps may involve cross-currency payments (U.S. Dollars vs. Mexican Pesos) and cross market payments, e.g., U.S. short-term rates vs. U.K. short-term rates.

❖ Functions/Use of Derivatives

Risk Management

- This is most important function of derivatives. Risk management is not about the elimination of risk rather it is about the management of risk.
- Financial derivatives provide a powerful tool for limiting risks that individuals and organizations face in the ordinary conduct of their businesses.
- It requires a thorough understanding of the basic principles that regulate the pricing of financial derivatives.
- Effective use of derivatives can save cost, and it can increase returns for the organizations.

Price Discovery

- The futures and options market provide an important function of price discovery.
- The individuals with better information and judgment are liable to participative in these markets to take advantage of such information.
- When some new information arrives, possibly some good news about the economy, for instance, the actions of speculators quickly feed their information into the derivatives markets causing changes in prices of the derivatives.
- As these markets are usually the first ones to react because the transaction cost is much lower in these markets than in the spot market.
- Therefore, these markets indicate what is likely to happen and thus assist in better price discovery.

Efficiency in Trading

- Derivative instruments allow for free trading of risk components and that leads to improving market efficiency.
- Usually derivative traders enter in derivative contract as an option for a position in underlying asset.
- In many occasions, traders find financial derivatives instrument to be a very attractive instrument than the underlying asset.
- This is mainly because of the greater amount of liquidity in the market offered by derivatives as well as the lower transaction costs associated with trading a financial derivative as compared to the costs of trading the underlying assets in equity cash market.

Speculation and Arbitrage

- Derivatives can be used to obtain risk, rather than to hedge against risk.
- Various traders enter into a derivative market to speculate on the price of the underlying asset.
- Speculators appear to purchase an asset in the future at a low price according to a derivative contract when the future market price is high, or to sell an asset in the future at a high price according to derivative contract when the future market price is low.
- Investors or traders may also look for arbitrage opportunities, as when the current buying price of an asset falls under the price specified in a futures contract to sell the asset.

Other Functions

- The other uses of derivatives are that the derivatives have smoothen out price fluctuations, compress the price spread, incorporate price structure at different points of time and take out gluts and deficiency in the markets.
- The derivatives also assist the investors, traders and managers of huge pools of funds to device such strategies so that they may make appropriate asset share raise their yields and achieve other investment targets.

❖ History of Derivative Markets

- History of financial markets is replete with crises. such as the breakdown of the fixed exchange rate system in 1971 and the Black Monday of October 1987 in US Markets, the steep fall in the Nikkei in 1989. the bond debacle of 1994 in US.
- All these events occur because of very high degree of volatility of financial markets and their unpredictability.
- With increased global integration of markets, such disasters have become more frequent.
- Since such volatility and associated disasters cannot be wished away, innovative financial instruments emerged to protect against these hazards.
- These included Futures and Options, which are the most dominant forms of financial derivatives.
- They are called derivatives because their prices depend on the values of other more basic underlying financial instruments.
- For example, the price of a stock option depends on the value of the underlying stock; a commodity futures price depends on the value of the underlying commodity and so on.
- These derivatives provide a mechanism, which market participants use to hedge their positions against adverse movement of variables over which they have no control.
- Financial derivatives came into the spotlight along with the growing instability in current markets during the post-1970 period, when the US announced its decision to give up gold-dollar parity, the basic king pin of the Bretton Woods System of fixed exchange rates.
- In less than three decades of their emergence, derivatives markets have become an integral part of modern financial system.

- The Indian financial markets took a giant leap ahead with the introduction of derivatives trading on the stock exchanges.
- The derivatives trading in India commenced with the introduction of index futures in June 2000.
- The advent of stock futures and options in 2001 resulted in a dramatic increase in the volumes of derivatives.
- In less than five years, the volumes in the Futures and Options segment rose more than that of the cash market.
- Since then, the volumes in the F&O segment have witnessed huge growth.
- Currently, the volumes in F&O are consistently around four to five times more than the cash market volumes.
- Derivatives trading commenced in India in June 2000 after SEBI granted the final approval to this effect in May 2000.
- SEBI permitted the derivative segments of two stock exchanges, viz NSE and BSE, and their clearing house/corporation to commence trading and settlement in approved derivative contracts.
- To begin with, SEBI approved trading in index futures contracts based on S&P CNX Nifty Index and BSE-30 (Sensex) Index.
- This was followed by approval for trading in options based on these two indices and options on individual securities.
- The trading in index options commenced in June 2001 and those in options on individual securities commenced in July 2001.
- Futures contracts on individual stock were launched in November 2001.

❖ Derivative Exchanges

In India there are various types of derivatives markets are there like Equity, commodity, Forex etc. and to cater different demands about these products there are different exchanges are there. Details of various exchanges are as below:

National Stock Exchange (NSE)

- The derivatives trading on the exchange commenced with S&P CNX Nifty Index futures on June 12,2000.
- The trading in index options commenced on June 4, 2001 and trading in options on individual securities commenced on July 2, 2001.
- Single stock futures were launched on November 9, 2001.
- The index futures and options contract on NSE are based on S&P CNX Nifty Index.
- Currently, the futures contracts have a maximum of 3-month expiration cycles.

Bombay Stock Exchange (BSE)

- Bombay Stock Exchange Limited (the Exchange) is the oldest stock exchange in Asia with a rich heritage.
- Popularly known as "BSE", it was established as "The Native Share & Stock Brokers Association" in 1875.
- It is the first stock exchange in the country to obtain permanent recognition in 1956 from the Government of India under the Securities Contracts (Regulation) Act, 1956.
- The Exchange's pivotal and pre-eminent role in the development of the Indian capital market is widely recognized and its index, SENSEX, is tracked worldwide.

- BSE created history on June 9, 2000 by launching the first Exchange traded Index Derivative Contract i.e. futures on the capital market benchmark index - the BSE Sensex.
- The inauguration of trading was done by Prof. J.R. Varma, member of SEBI and chairman of the committee responsible for formulation of risk containment measures for the Derivatives market.
- In the sequence of product innovation, the exchange commenced trading in Index Options on Sensex on June 1,2001.
- Stock options were introduced on 31 stocks on July 9, 2001 and single stock futures were launched on November 9, 2002.
- September 13, 2004 marked another milestone in the history of Indian Capital Markets, the day on which the Bombay Stock Exchange launched Weekly Options, a unique product unparallel in derivatives markets, both domestic and international.
- BSE permitted trading in weekly contracts in options in the shares of four leading companies namely Reliance, Satyam, State Bank of India, and Tisco in addition to the flagship index-Sensex.

❖ Commodity Exchange in India

- Commodity markets have existed in India for a long time. While the implementations of the Kabra committee recommendations were rather slow.
- Today, the commodity derivative market in India seems poised for a transformation.
- National level commodity derivatives exchanges seem to be the new phenomenon.
- The Forward Markets Commission accorded in principle approval for the following national level multi commodity exchanges.

- The increasing volumes on these exchanges suggest that commodity markets in India seem to be a promising game.
  - National Board of Trade
  - Multi Commodity Exchange of India (MCX)
  - National Commodity & Derivatives Exchange of India (NCDX)

❖ Trading System

- A future trading is an important economic activity for the development of an economy.
- Being the first form of derivatives trading, it is a specialized field which requires professional expertise and adequate knowledge in this area.
- To be a successful market operator (as a speculator, arbitrageur, trader, investor or hedger) one must have adequate information and proper understanding of the functioning of the futures markets.
- These are essential to make evaluation of derivatives products in terms of their prices and values so that the market participants can select them as per their objectives.
- Futures are useful to the market participants only if futures prices reflect information about the prices of the underlying assets.
- That is why it is essential to understand how futures markets work and how the prices of futures contracts relate to the spot prices.

Futures and Options Trading System

- The futures & options trading system of NSE, called NEAT-F&O trading system, provides a fully automated screen-based trading for Nifty futures & options and stock futures & options on a nationwide basis as well as an online monitoring and surveillance mechanism.

- It supports an order driven market and provides complete transparency of trading operations.
- It is similar to that of trading of equities in the cash market segment.

Entities in the Trading System

1. Trading members:

- Trading members are members of NSE. They can trade either on their own account or on behalf of their clients including participants.
- The exchange assigns a trading member ID to each trading member.
- Each trading member can have more than one user.
- The number of users allowed for each trading member is notified by the exchange from time to time.
- Each user of a trading member must be registered with the exchange and is assigned a unique user ID.
- The unique trading member ID functions as a reference for all orders/traders of different users.
- This ID is common for all users of a particular trading member.

2. Clearing members:

- Clearing members are members of NSCCL.
- They carry out risk management activities and confirmation/inquiry of trades through the trading system.

3. Professional clearing members:

- A professional clearing member is a clearing member who is not a trading member.
- Typically, banks and custodians become professional clearing members and clear and settle for their trading members.

4. Participants:

- A participant is a client of trading members like it financial institutions.
- These clients may trade through multiple trading members but settle through a single clearing member.

❖ Types of Traders

- Traders play a vital role in the futures markets by providing liquidity.
- While futures are designed primarily to assist hedgers in managing their exposure to price risk, the market would not be possible without the participation of traders, or speculators, who provide a fluid market of
- buyers and sellers.
- Speculators provide the bulk of market liquidity, which allows the hedger to enter and exit the market in a more efficient manner.

Hedgers

- These are investors with a present or anticipated exposure to the underlying asset which is subject to price risks. Hedgers use the derivatives markets primarily for price risk management of assets and portfolios.
- Example: An importer has to pay US $ to buy goods and rupee is expected to fall to Rs.50/$ from Rs.48/$, then the importer can minimize his losses by buying a currency future at Rs.49/$.

Speculators

- These are individuals who take a view on the future direction of the markets.
- They take a view whether prices would rise or fall in future and accordingly buy or sell futures and options to try and make a profit from the future price movements of the underlying asset.
- Example: If you will the stock price of Reliance is expected to go up to Rs.400 in 1 month, one can buy a 1-month future of Reliance at Rs.350 and make profits.

Arbitragers

- These are the third important participants in the derivatives market.
- They take positions in financial markets to earn risk less profits.
- The arbitragers take short and long positions in the same or different contracts at the same time to create a position which can generate a risk less profit.
- Example: A futures price is simply the current price plus the interest cost. If there is any change in the interest, it presents an arbitrage opportunity.

❖ Trading Process, Online Trading

❖ Clearing and Settlement System

- National Securities Clearing Corporation Limited (NSCCL) undertakes clearing and settlement of all trades executed on the futures and options (F&O) segment of the NSE.
- It also acts as legal counterparty to all trades on the F&O segment and guarantees their financial settlement.
- In order to encourage an institutional market where large volume trades come up for settlement in jumbo lots, two exclusive additional market segments, the institutional lot segment and trade-for-trade segment have been set up.
- NSE has an order driven system, which allows members to undertake jobbing in securities of their choice.
- Several members undertake jobbing on account of the cease of entry and exit, and narrow margins which results in improved liquidity and reduced transaction costs.

- **Clearing Entities**

- A Clearing Member (CM) of NSCCL has the responsibility of clearing and settlement of all deals executed by Trading Members (TM) on NSE, who clear and settle such deals through entities.
- Clearing and settlement activities in the F&O segment are undertaken by NSCCL with the help of the following entities:

1. Clearing Members

- In the F&O segment, some members, called self-clearing members, clear and settle their trades executed by them only either on their own account or on account of their clients.

- Some others called trading member-cum-clearing member, clear and settle their own trades as well as trades of other trading members (TMs).

- Besides, there is a special category of members, called professional clearing members (PCM) who clear and settle trades executed by TMs.
- The members clearing their own trades and trades of others, and the PCMs are required to bring in additional security deposits in respect of every TM whose trades they undertake to clear and settle.
- Primarily, the CM performs the following functions:
  i. Clearing
  ii. Settlement
  iii. Risk Management

2. Clearing Banks

- Funds settlement takes place through clearing banks.
- For the purpose of settlement all clearing members are required to open a separate bank account with NSCCL designated clearing bank for F&O segment.
- Every Clearing Member is required to maintain and operate clearing accounts with any of the empaneled clearing banks at the designated clearing bank branches.
- The clearing accounts are to be used exclusively for clearing & settlement operations.

Clearing Mechanism

- The clearing mechanism essentially involves working out open positions and obligations of clearing (self-clearing/trading-cum-clearing/professional clearing) members.

- This position is considered for exposure and daily margin purposes.

- The open positions of Clearing members (CMs) are arrived at by aggregating the open positions of all the trading members (TMs) and all custodial participants clearing through him, in contracts in which they have traded.
- A TM's open position is arrived at as the summation of his proprietary open position and clients' open positions, in the contracts in which he has traded.
- While entering orders on the trading system, TMs are required to identify the orders, whether proprietary (if they are their own trades) or client (if entered on behalf of clients) through 'Pro/Cli' indicator provided in the order entry screen.
- Proprietary positions are calculated on net basis (buy - sell) for each contract.
- Clients' positions are arrived at by summing together net (buy - sell) positions of each individual client.

- Example: Given from Table 11.1 to Table 11.4. The proprietary open position on day 1 is simply = Buy - Sell = 200 - 400 = 200 short. The open position for client A = Buy (O) - Sell (C) = 400 – 200 = 200 long, i.e. he has a long position of 200 units. The open position for Client B = Sell (O) – Buy(C) = 600 – 200 = 400 short, i.e. he has a short position of 400 units. Now the total open position of the trading member Mr. X at end of day 1 is 200 (his proprietary open position on net basis) plus 600 (the Client open positions on gross basis), i.e. 800.
- The proprietary open position at end of day 1 is 200 short. The end of day open position for proprietary trades undertaken on day 2 is 200 short. Hence the net open proprietary position at the end of day 2 is 400 short. Similarly, Client A's open position at the end of day 1 is 200 long. The end of day open position for trades done by Client A on day 2 is 200 long. Hence the net open position for Client A at the end of day 2 is 400 long. Client B's open position at the end of day 1 is 400 short. The end of day open position for trades done by Client B on day 2 is 200 short. Hence the net open position for Client B at the end of day 2 is 600 short. The net open position for the trading member at the end of day 2 is sum of the proprietary open position and client open positions. It works out to be 400 + 400 + 600, i.e. 1400.

Table 11.1: Proprietary position of trading member Mr. X on Day 1

Trading member Mr. X trades in the futures and options segment for himself and two of his clients. The table shows his proprietary position.

Note: A buy position "200@1000" means 200 units bought at the rate of ₹ 100.

	Trading member Mr. X			
	Proprietary position	Buy	Sell	
		200 @ 1000	400 @100	

Table 11.2: Client position of trading member Mr. X on Day 1

Trading member Mr. X trades in the futures and options segment for himself and two of his clients. The table shows his client position.

	Trading member Mr. X					
		Buy Open	Sell Close	Sell Open	Buy Close	
	Client Position					
	Client A	400@1109	200@100			
	Client B			600@1100	400@1000	

Table 11.3: Proprietary Position of Trading Member Mr. X on Day 1

Assume that the position on Day 1 is carried forward to the next trading day and the following trades are also executed.

	Trading member Mr. X			
		Buy	Sell	
	Proprietary position	200 @ 1000	400 @100	

Table 11.4 Client Position of Trading Member Mr. X on Day 1

Trading member Mr. X trades in the futures and options segment for himself and two of his clients. The table shows his client position on Day 2.

	Trading member Mr. X					
		Buy Open	Sell Close	Sell Open	Buy Close	
	Client Position					
	Client A	400@1109	200@100			
	Client B			600@1100	400@1000	

❖ Settlement Mechanism

- All futures and options contracts are cash settled through exchange of cash.
- The underlying for index futures/options of the Nifty index cannot be delivered.
- These contracts, therefore, have to be settled in cash.
- However, it has been currently mandated that stock options and futures would also be cash settled.
- The settlement amount for a CM is netted across all their TMs/clients, with respect to their obligations on MTM, premium and exercise settlement.

Table 11.5: Determination of open Position of Clearing Member

TMs Clearing Through CM	Proprietary trades			Trades: Client 1			Trades: Client 2				
	Buy	Sell	Net	Buy	Sell	Net	Buy	Sell	Net	Long	Short
ABC	4000	2000	2000	3000	1000	2000	4000	2000	2000	6000	-
PQR	2000	3000	(1000)	2000	1000	1000	1000	2000	(1000)	1000	2000
Total	6000	5000	+2000	5000	2000	+3000	5000	4000	+2000	7000	2000
			-1000						-1000		

❖ Regulatory Framework of Derivatives Market in India

Following are important eligibility/regulatory conditions specified by SEBI:

- Derivative trading to take place through an on screen-based trading system.
- The derivatives exchange/segment should have on-line surveillance capability to monitor positions, prices and volumes on a real time basis so as to deter market manipulation.
- The derivatives exchange/segment should have arrangements for dissemination of information about trades, quantities and quotes on a real time basis through at least two information vending networks, which are easily accessible to investors across the country.
- The derivatives exchange/segment should have arbitration and investor grievances redressal mechanism operative from all the four areas/regions of the country.
- The derivatives exchange/segment should have a satisfactory system of monitoring investor complaints and preventing irregularities in trading.
- The derivative segment of the exchange would have a separate Investor Protection Fund.
- The clearing corporation/house will perform full novation, i.e., the clearing corporation/house will interpose itself between both legs of every trade, becoming the legal counterparty to both or alternatively should provide an unconditional guarantee for settlement of all trades.
- The clearing corporation/house should have the capacity to monitor the overall position of members across both derivatives market and the underlying securities market for those members who are participating in both.
- The level of initial margin on index futures contracts will be related to the risk of loss on the position. The concept of value-at-risk will be used in calculating the required level of initial margins.

- The clearing corporation/house will establish facilities for electronic funds transfer (EFT) for swift movement of margin payments.
- In the event of a member defaulting in meeting its liabilities, the clearing corporation/house shall transfer client positions and assets to another solvent member or close-out all open positions.
- The clearing corporation/house should have capabilities to segregate initial margins deposited by clearing members for trades on their own account and on account of his client. The clearing corporation/house will hold the clients' margin money in trust for the client purposes only and should not allow its diversion for any other purpose.
- The clearing corporation/house should have a separate Trade Guarantee Fund for the trades executed on derivative exchange/segment.

Subject: Financial Derivatives (4539292)

MBA SEM 03
Module 02

❁ FORWARD CONTRACTS ❁

❖ Introduction

- A Forward Contract is a contract made today for delivery of an asset at a pre-specified time in the future at a price agreed upon today.
- The buyer of a forward contract agrees to take delivery of an underlying asset at a future time (T), at a price agreed upon today.
- No money changes hands until time T.
- The seller agrees to deliver the underlying asset at a future time T, at a price agreed upon today.
- Again, no money changes hands until time T.
- A forward contract, therefore, simply amounts to setting a price today for a trade that will occur in the future.
- In other words, a forward contract is a contract between two parties who agree to buy/sell a specified quantity of a financial instrument/commodity at a certain price at a certain date in future.

❖ Forward Contracts

- A forward contract is a simple customized contract between two parties to buy or sell an asset at a certain time in the future for a certain 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.
- A forward contract is an agreement between two parties to buy or sell underlying assets at a pre-determined future date at a price agreed when the contract is entered into.
- Forward contracts are not standardized products. They are over-the-counter (not traded in recognized stock exchanges) derivatives that are tailored to meet specific user needs.
- The underlying assets of this contract include:
    1. Traditional agricultural or physical commodities
    2. Currencies (foreign exchange forwards)
    3. Interest rates (forward rate agreements or FRAs)

- At the time the forward contract is written, a specified price is fixed at which the asset is purchased or sold.
- This delivery price is referred to as the delivery price.
- This delivery price is set such that the either a long (buyer) or a short (seller) position.
- This is done by convention so that no cash is exchanged between the parties entering into the contracts.
- In this way, the delivery price yields a ‘fair’ price for the future delivery of the underlying asset.
- One of the parties to a forward contract agrees to buy the underlying asset is aid to have a ‘long’ position.
- On the other hand, the party that agrees to sell the same underlying asset is said to have a ‘short’ position.

➢ Forward Terminologies

- **Underlying Asset**: This refers to the asset on which forward contract is made i.e., the long position holder buys this asset in future and the short position holder sells this asset in future. The various underlying assets are equity shares, stock indices, commodity, currency, interest rate, etc.
  For example, in the above case, sugar (a commodity) is the underlying asset.

- **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.
  For example, in the above case, Mr. Y is said to hold a long position. The long position holder on the contract agree to buy the underlying asset on the future date because they are betting the price will go up.

- **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.

- **Spot Position**: This is the quoted price of the underlying asset for buying and selling at the spot time or immediate delivery.

- **Future Spot Price**: This is the spot price of the underlying asset on the date the forward contract expires and it depends on the market condition prevailing at the expiration date.

- **Expiration Date**: This is the date on which the forward contract expires or also referred to as maturity date of the contract. For example, in the above case, the expiry date is 1st July, 2011.

- **Delivery Price**: The pre-specified price of the underlying assets at which the forward contract is settled on expiration is said to be delivery price.

❖ Benefits of Forward Markets

- Forward contracts can be used to hedge or lock-in the price of purchase or sale of commodity or financial asset on the future commitment date.
- On forward contracts, generally, margins are not paid and there is also no upfront premium. So, it does not involve initial cost.
- Since forwards are tailor-made, price risk exposure can be hedged up to 100%, which may not be possible in futures or options.

❖ Limitations of Forward Markets

- Lack of centralization of trading,
- Illiquidity, and
- Counterparty risk
- Counterparty risk is very much present in a forward contract since there is no performance guarantee. On due date, the possibility of counterparty's failure to perform his obligation creates another risk exposure.
- Forward contracts do not allow the investor to derive any gain from favorable price movement or to unwind the transactions once the contract is made. At the most, the contract can be cancelled on the terms agreed upon by the counterparty.
- Since forwards are not exchange-traded, they have no ready liquidity. Further, it is difficult to get counterparty on one's terms.

❖ Pricing of Forward Contracts

- In the first place, we will develop rules for-determining prices of the forward contracts and then use these to obtain the prices of futures contracts. In particular, we consider the three cases listed below:
    1. For securities providing no income.
    2. For securities providing a given amount of income.
    3. For securities providing a known yield.

1) Securities Providing No Income

- This is the easiest forward contract for valuation, 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 F should be:

$$\mathbf{F = S_0 e^{rt}}$$

- Here, $\mathbf{S_0}$ 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, assume that $\mathbf{F > S_0 e^{rt}}$. In this case, an investor may buy the asset by borrowing an amount equal to S_0 for a period of t at the risk-free rate, and take a short position in forward contract.
- At the time of maturity, the asset will be delivered for a price of F and the amount borrowed will be repaid by paying an amount equal to $\mathbf{S_0 e^{rt}}$ and the deal would result in a net profit of $\mathbf{F - S_0 e^{rt}}$.
- Similarly, if $\mathbf{F < S_0 e^{rt}}$, then the investor would do well to short the asset, invest the proceeds for the time period t at an interest rate of r per annum, and long a forward contract. When the contract matures, the asset would be purchased for a price of F and the short position in the asset would be closed out. This would result in a profit'of $\mathbf{S_0 e^{rt} - F}$.

- **Example**: Consider a forward contract on a non-dividend paying share which is available at Rs 70, to mature in 3-months' time. If the risk-free rate of interest be 8% per annum compounded continuously, the contract should be priced at $70e^{(0.25)(0.08)}$ or Rs 70 x 1.0202 = Rs 71.41.

- If the forward contract was priced at a higher value than this, say at Rs 73, an arbitrageur should short a contract, borrow an amount of Rs 70 for three months at the risk-free rate, and buy the share for Rs 70. At maturity, sell the share for Rs 73 (forward contract price), repay the loan amount of Rs 71.40 and make a profit of Rs 73 – Rs 71.40 = Rs 1.60. In a similar way, if the forward contract was quoted at Rs 71, then the investor should buy a contract, short a share and invest the amount realized for three months, to get Rs 71.40 back after this period. Then the share would be bought for Rs 71 and replaced. This would result in a net gain of Rs 0.40.

2) Securities Providing a Known Cash Income

- We may now consider a forward contract on a security which provides a certain cash income to the investor. Preference shares are an example of this.
- In such a case, we first determine the present value of the income receivable.
- For instance, if the income Y is receivable in two months' time from now and r is the discount rate per annum (compounded continuously), then the present value I, of income Y would be $I = Ye^{(-2/12)r}$.
- Now, if there is to be no arbitrage, then the price of the forward contract should be $F = (S_0 – I)e^{rt}$.
- In the same manner as discussed earlier, first suppose that $F > (S_0 – I)e^{rt}$.
- Here an arbitrageur can short a forward contract, borrow money and buy the asset. When the income is received, it is used to partly repay the loan.
- At maturity, the asset is sold for F and the outstanding loan of $(S_0 – I)e^{rt}$ is repaid.
- This result in a net profit of $F - (S_0 – I)e^{rt}$.

- On the other hand, $F < (S_0 - I)e^{rt}$, then an arbitrageur can short the asset, invest the proceeds, and take a long position in a forward contract.
- This operation will yield a net gain of $(S_0 - I)e^{rt} - F$ at maturity.

- Let us consider a 6-month forward contract on 100 shares with a price of Rs 38 each. The risk-free rate of interest (continuously compounded) is 10% per annum. The share in question is expected to yield a dividend of Its 1.50 in 4 months from now. We may determine the value of the forward contract as follows:

Dividend receivable after 4 months	=	100 x 1.50 = Rs 150
Present value of the dividend, I	=	$150_e{}^{-(4/12)(0.10)}$
	=	150 x 0.9672 or Rs 145.08
Value of forward contract	=	$(3800 - 145.08)_e{}^{(0.5)(0.10)}$
		3654.92 x 105127
	=	Rs 3842.31

3) Securities Providing a Known Yield

- While in Case 2, we considered pricing of forward contracts for securities that provide a known amount of income, we now look at the case of securities which 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 may be calculated as follows:

$$\mathbf{F = S_0e^{(r-y)t}}$$

- **Example:** Assume that the stocks underlying an index provide a dividend yield of 4% per annum, the current value of the index is 520 and that the continuously compounded risk-free rate of interest is 10% per annum. To find the value of a 3-month forward contract, we proceed as follows:
- Here, S_0 = 520, r = 0.10, y = 0.04, and t = 3/12 or 0.25.
- Accordingly, the forward price can be computed as

$$F = 520e^{(0.10 - 0.04)(0.25)}$$
$$= 520 * 1.0151$$
$$= \text{Rs } 527.85$$

❖ Interest Rate Forwards (Theory and numerical)

FUTURE CONTRACTS

Introduction

- A futures contract is a type of derivative instrument, or financial contract, in which two parties agree to transact a set of financial instruments or physical commodities for future delivery at a particular price.
- If you buy a future contract, you are basically agreeing to buy something that a seller has not yet produced for a set price.
- But participating in the futures market does not necessarily mean that you will be responsible for receiving or delivering large inventories of physical commodities remember, buyers and sellers in the futures market primarily enter into futures contracts to hedge risk or speculate rather than to exchange physical goods (which is the primary activity of the cash/spot market).
- That is why futures are used as financial instruments by not only producers and consumers but also by speculators.

Futures Contracts

- A future contract is a standardized agreement between the seller (short position) of the contract and the buyer (long position), traded on a futures exchange, to buy or sell a certain underlying instrument 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.
- Thus, futures is a standard contract in which the seller is obligated to deliver a specified asset (security, 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.

- Pricing can be based on an open outcry system, or bids and offers can be matched electronically.
- The futures contract will state the price that will be paid and the date of delivery.

❖ Difference Between Forward and Future Contracts

Table 4.1: Distinction between Forwards and Futures

Criteria / Factors		Forwards	Futures
1.	Trading	Traded by telephone or telex (OTC)	Traded in a competitive arena (recognised exchange)
2.	Size of contracts	Decided between buyer and seller	Standardised in each futures market
3.	Price of contract	Remains fixed till maturity	Changes everyday
4.	Mark to Market	Not done	Marketed to market everyday
5.	Margin	No margin required	Margins are to be paid by both buyer and sellers
6.	Counter Party Risk	Present	Not present
7.	Number of contracts in a year	There can be any number of contracts	Number of contracts in a year is fixed.
8.	Frequency of Delivery	90% of all forward contracts are settled by actual delivery.	Very few future contracts are settled by actual delivery
9.	Hedging	These are tailor-made for specific date and quantity. So, it is perfect	Hedging is by nearest month and quantity contracts. So, it is not perfect.
10.	Liquidity	Not liquidity	Highly liquid
11.	Nature of Market	Over the Counter	Exchange traded
12.	Mode of Delivery	Specifically decided. Most of the contracts result in delivery	Standardised. Most of the contracts are cash-settled.
13.	Transactional Costs	Costs are based on bid-ask spread	Include brokerage fees for buy and sell others

❖ Standardization/Specifications of Futures Contracts

Thus, futures contracts are highly standardized, to ensure that they are liquid. The standardization usually involves specifying:

- The underlying this can be anything from a barrel of crude oil to a short-term interest rate;
- The type of settlement, either cash settlement or physical settlement;
- The amount and units of the underlying asset per contract. This can be the notional amount of bonds, a fixed number of barrels of oil, units of foreign currency, the notional amount of the deposit over which the short-term interest rate is traded, etc.;
- The currency in which the futures contract is quoted;
- The grade of the deliverable. In the case of bonds, this specifies which bonds can be delivered. In the case of physical commodities, this specifies not only the quality of the underlying goods but also the manner and location of delivery;
- The delivery month;
- The last trading date;
- Other details such as commodity tick, the minimum permissible price fluctuation.

❖ Closing the position (Theory and numerical)

❖ MARGINS

- Like all exchanges, only members are allowed to trade in futures contracts on the exchange. Others can use the services of the members as brokers to use this instrument.
- Thus, an exchange member can trade on his own account as well as on behalf of a client.
- A subset of the members is the "clearing members" or members of the clearing house and non-clearing members must clear all their transactions through a clearing member.
- The exchange requires that a margin must be deposited with the clearing house by a member who enters into a futures contract.
- The amount of the margin is generally between 2.5 per cent to 10 per cent of the value of the contract but can vary.
- A member acting on behalf of a client, in turn, requires a margin from the client.
- The margin can be in the form of cash or securities like treasury bills or bank letters of credit.

➢ Initial Margin

- Initial margin is the percentage of the purchase price of securities (that can be purchased on margin) that the investor must pay for with his own cash or marginable securities; it is also called the initial margin requirement.
- According to Regulation T of the Federal Reserve Board, the initial margin is currently 50 per cent, but this level is only a minimum and some brokerages require you to deposit more than 50 per cent.
- For futures contracts, initial margin requirements are set by the exchange.
- A margin account enables investors to use leverage and purchase more securities than the cash balance in their account would allow.

- A margin account is essentially a loan account in which interest is charged on the outstanding margin balance.
- The securities purchased in the margin account are purchased with cash loaned to the investor by the broker, and the securities themselves are used as collateral.
- This allows for a potential magnification in gains, but also losses.
- In the extreme event that the securities purchased on margin decline to zero, the investor would need to deposit the full initial value of the securities in cash to cover the loss.

➢ **Maintenance Margin**

- Maintenance margin is the minimum amount of equity that must be maintained in a margin account.
- In the context of the NYSE and FINRA, after an investor has bought securities on margin, the minimum required level of margin is 25 per cent of the total market value of the securities in the margin account.
- Keep in mind that this level is a minimum, and many brokerages have higher maintenance requirements of 30-40 per cent.
- Maintenance margin is also referred to as "minimum maintenance" or "maintenance requirement."

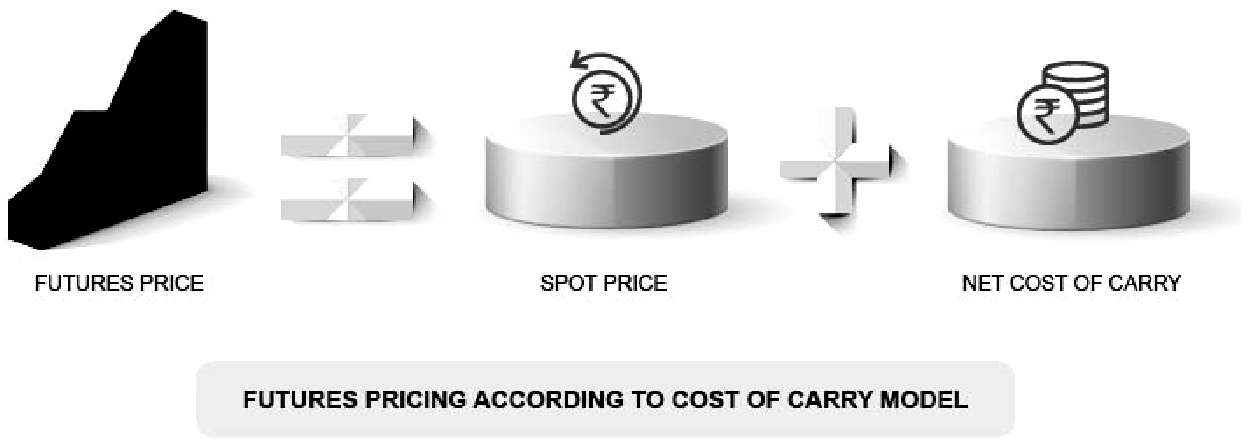
➢ **Example**: suppose an investor buys two gold futures contracts. The initial margin is $2,000 per contract (or $4,000 for two contracts) and the maintenance margin is $1,500 per contract (or $3,000 for two contracts). The contract is entered into on June 5 at $850 and closed out on June 18 at $840.50. (Gold is trading around $1,200 per ounce now)

Day	Futures price (settlement)	Daily gain (loss)	Cumulative gain (loss)	Margin balance	Margin call (variation margin)
	850.00			4,000	
June 5	848.00	(400)	(400)	3,600	
June 6	847.50	(100)	(500)	3,500	
June 9	848.50	200	(300)	3,700	
June 10	846.00	(500)	(800)	3,200	
June 11	844.50	(300)	(1,100)	2,900	Yes (1,100)
June 12	845.00	100	(1,000)	4,100	
June 13	846.50	300	(700)	4,400	
June 16	842.50	(800)	(1,500)	3,600	
June 17	838.00	(900)	(2,400)	2,700	Yes (1,300)
June 18	840.50	500	(1,900)	4,500	

❖ MARK TO MARKET (VARIATION MARGIN)/MARKING TO MARKET MARGIN

- The exchange uses a system called marking to market where, at the end of each trading session, all outstanding contracts are reprised at the settlement price of that trading session.
- This would mean that some participants would make a loss while others would stand to gain.
- The exchange adjusts this by debiting the margin accounts of those members who made a loss and crediting the accounts of those members who have gained.
- This feature of futures trading creates an important difference between forward contracts and futures.
- In a forward contract, gains or losses arise only on maturity. There are no intermediate cash flows.
- Whereas, in a futures contract, even though the gains and losses are the same, the time profile of the accruals is different.
- In other words, the total gains or loss over the entire period is broken up into a daily series of gains and losses, which clearly has a different present value.

❖ COST OF CARRY MODEL

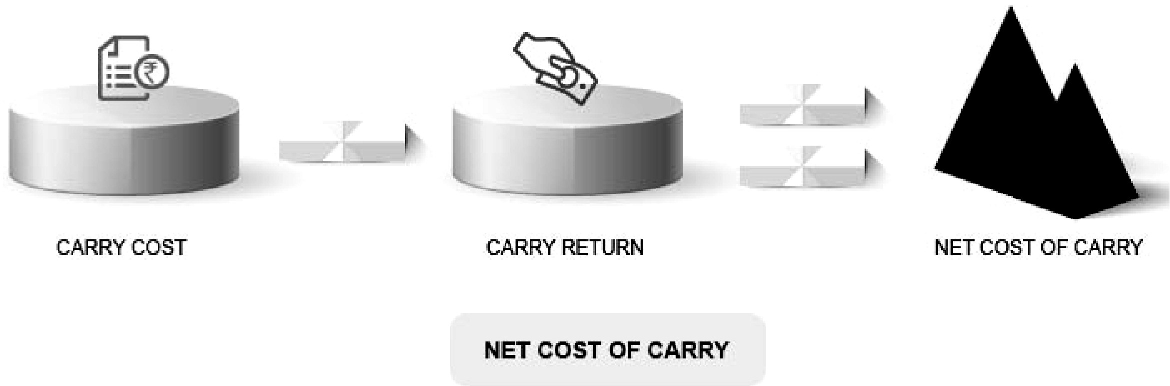


- The Cost of Carry Model assumes that markets tend to be perfectly efficient. This means there are no differences in the cash and futures price.
- This, thereby, eliminates any opportunity for arbitrage – the phenomenon where traders take advantage of price differences in two or more markets.
- When there is no opportunity for arbitrage, investors are indifferent to the spot and futures market prices while they trade in the underlying asset.
- This is because their final earnings are eventually the same.
- The model also assumes, for simplicity sake, that the contract is held till maturity, so that a fair price can be arrived at.
- In short, the price of a futures contract (FC) will be equal to the spot price (SP) plus the net cost incurred in carrying the asset till the maturity date of the futures contract.

FC = SP + (Carry Cost – Carry Return)

- Here Carry Cost refers to the cost of holding the asset till the futures contract matures.
- This could include storage cost, interest paid to acquire and hold the asset, financing costs, etc.

- Carry Return refers to any income derived from the asset while holding it like dividends, bonuses, etc.
- While calculating the futures price of an index, the Carry Return refers to the average returns given by the index during the holding period in the cash market.
- A net of these two is called the Net Cost of Carry.
- The bottom line of this pricing model is that keeping a position open in the cash market can have benefits or costs.
- The price of a futures contract basically reflects these costs or benefits to charge or reward you accordingly.



❖ BID AND ASK PRICES

- Bid prices are those provided by Buyers who want to buy shares or futures or other products at these Bid prices.
- Ask prices are those quoted by Sellers who want to sell shares or futures or other products at these Ask prices.
- The difference between Bid and Ask Prices is called as the Bid-Offer spread and also sometimes referred to as the Jobbing Spread.
- In highly liquid markets, the Bid-Offer Spread is small.
- In illiquid markets, the spread is high.
- The difference between Bid and Ask Prices is also called impact cost.
- If liquidity is poor, impact cost is high and vice versa.

❖ SETTLEMENT PRICES

- Daily settlement price on a trading day is the closing price of the respective futures contracts on such day.
- The closing price for a futures contract is currently calculated as the last half an hour weighted average price of the contract in the F&O Segment of BSE.
- Final settlement price is the closing price of the relevant underlying index/security in the capital market segment of BSE, on the last trading day of the contract.
- The closing price of the underlying Index/security is currently its last half an hour weighted average value in the capital market segment of BSE.

❖ OPEN INTEREST

- Open interest is the number of futures contracts outstanding. It reduces to zero upon maturity of the contract.
- Example:

Time	Actions	Open Interest
t=0	Trading opens for gold contract	0
t=1	Trader A buys 2 and trader B sells 2 gold contracts	2
t=2	Trader A sells 1 and trader C buys 1 gold contract	2
t=3	Trader D sells 2 and trader C buys 2 gold contracts	4

❖ TYPES OF ORDERS

- The derivatives market is order driven i.e. the traders can place only orders in the system.
- Following are the order types allowed for the derivative products. These order types have characteristics similar to the ones in the cash market.

1. **Limit Order**: An order for buying or selling at a limit price or better, if possible. Any unexecuted portion of the order remains as a pending order till it is matched or its duration expires.
2. **Market Order:** An order for buying or selling at the best price prevailing in the market at the time of submission of the order. There are two types of Market Orders:
    i. **Partial Fill Rest Kill (PF):** execute the available quantity and kill any unexecuted portion.
    ii. **Partial Fill Rest Convert (PC):** execute the available quantity and convert any unexecuted portion into a limit order at the traded price.
3. **Stop Loss:** An order that becomes a limit order only when the market trades at a specified price.

HEDGING, SPECULATION AND ARBITRAGE USING FUTURES

Introduction

- To be successful, a futures market basically needs to have two types of participants: hedgers and speculators. The markets simply cannot exist without hedgers and the speculators cannot then perform any economic function.

Hedgers:

- In the context of futures contracts, a hedger is one who is engaged in a business activity where an unacceptable price risk exists.
- For example, a farmer might be worried about the price the wheat grown by him would fetch, when the crop is ready.
- His fortunes depend on the price he can obtain for his produce.
- If the price is indeed high, the farmer would earn a fair amount of profit.
- Should the price, however, be low because of, say abundant supplies, he might not be able to make a reasonable profit, or might even run into losses.
- To reduce this risk, the farmer may choose to hedge in the futures market.
- He can do so by selling futures contracts.
- Thus, suppose it is November now and the April wheat is being sold for Rs 820 per quintal.
- Assume that the farmer finds this price is attractive because it provides for a reasonable level of profit and eliminates price risk associated with growing wheat.
- The farmer can hedge the price risk by agreeing to sell his produce at Rs 820-per quintal to someone who agrees to take a long position.

- Thus, the farmer is assured of this price for his-crop and not worry if the price were to fall subsequently.
- In agricultural commodities, the hedger usually goes short in the futures market because the farmer wants to deliver his produce. This is called short hedge.
- However, hedging may also involve taking long position.
- To illustrate, if a jewellery firm takes an export order for some jewellery to be supplied after 4 months, it may like to guard itself against the possible adverse movement in the price of gold by taking long position in the futures market. This is termed long hedge.

➢ **Speculators:**

- While the hedgers avoid the price risk, the speculators are the class of participants in the futures markets who are willing to bear the risk.
- Obviously, for the hedgers to eliminate the unacceptable price risk, they must find those who are prepared to take such risk.
- Of course, both long and short hedgers may be present in the market so that entering into a transaction may be to their mutual benefit.
- But since at any moment, they usually are not present in equal numbers, the speculators step in and provide a vital economic function.
- Speculators are such people who are financially capable of bearing such risk.
- In fact, the speculative demand for futures contracts is much greater in volume and frequency than the hedging demand.
- A speculator does not have an economic activity that requires the use of futures but rather finds investment opportunities in the futures markets and takes positions in an attempt to make profit from price movements.
- A speculator would take long position in a futures contract if he feels that prices are likely to rise and a short position if he feels otherwise.
- Since price increases are relatively easier to visualize, speculators generally take long positions.

- However, if the prices are believed to go down, they assume short positions-as well.
- Notice here that a speculator taking a short position in a wheat contract is not a producer of wheat and, therefore, does not intend to eventually supply it on the date of maturity of the contract.
- Instead, he would take a long position in such a contract and, therefore, cancel the original position and making profit/loss as the difference between the prices he agreed for in the two positions.
- Evidently, speculators' role in the futures markets is much like that of an insurance company.
- The speculators provide liquidity (implying continuous presence of buyers and sellers) that helps to make the futures markets an efficient hedging mechanism.
- Further, by putting their money on the prices, the speculators aid in the process of price discovery, thus performing an important economic function.

➢ **Scalpers:**

- Scalpers represent another type of traders who play a crucial role in the economic functioning of the futures markets.
- They are the individuals who engage in continuous buying and selling of contracts on their own behalf.
- They-work on low margins but their continuous trading enables them to make good profits on their operations.
- Of course, when the markets show greater volatility, they can make handsome; profits.
- The presence of scalpers ensures the futures prices to be both continuous and accurate, thus imparting liquidity to the markets in a good measure.

➢ Arbitrageurs:

- Another group of participants in futures markets is that of the arbitrageurs.
- The arbitrageurs do not take view on-prices, like speculators do.
- They thrive on inefficiencies of the market and so their actions help keep the market efficient and functioning well.
- The arbitrageurs come into action once they find that the prices in the spot market and the futures market, or in the futures market in respect of different maturities are deviating from the "normal".
- For example, if an arbitrageur finds that prices of futures contracts with a certain maturity date is higher than what should it be in accordance with the price in the spot market, he would step in to short futures contracts and buy in the spot market.
- With more and more people taking similar positions, the futures prices would tend to fall relative to spot price.
- As the gap between the two prices narrows, the arbitrageur would earn profit.

❖ BASIS RISK

- Hedging usually cannot be perfect for the following reasons:
- The asset whose price is to be hedged may not be exactly the same as the asset underlying the futures contract (e.g., stock index futures and your stock portfolio)
- The hedger may be uncertain as to the exact date when the asset will be bought or sold
- The hedge may require the futures contract to be closed out well before its expiration date

Basis (B) = Spot Price (S) - Futures Price (F)

- Let S_1, F_1, and b_1 be the spot price, futures price, and basis at time t_1 and S_2, F_2, and b_2 be the spot price, futures price, and basis at time t_2, then $b_1 = S_1 - F_1$ at time t_1 and $b_2 = S_2 - F_2$ at time t_2.
- Consider a hedger who knows that the asset will be sold at time t_2 and takes a short position at time t_1. The spot price at time t_2 is S_2 and the payoff on the futures position is $(F_1 - F_2)$ at time t_2. The effective price is

  $S_2 + F_1 - F_2 = F_1 + b_2$, where b_2 refers to the basis risk

➢ Basis Risk in a Short Hedge

- Suppose it is March 1 (t_1). You expect to receive 50 million yen at the end of July (t_2). The September futures price (exchange rate) is currently 0.8900 dollar for 100 yen.

- **Hedging Strategy:**
  A. Sell four September yen futures contracts on March 1 (Since the contract size is 12.5 million yen 4 contracts will cover 50 million yen)
  B. Close out the contracts when yen arrives at the end of July

- **Basis Risk:**

  arises from the uncertainty as to the difference between the spot price and September futures price of yen at the end of July ($S_2 - F_2 = b_2$)

- **Outcome:**

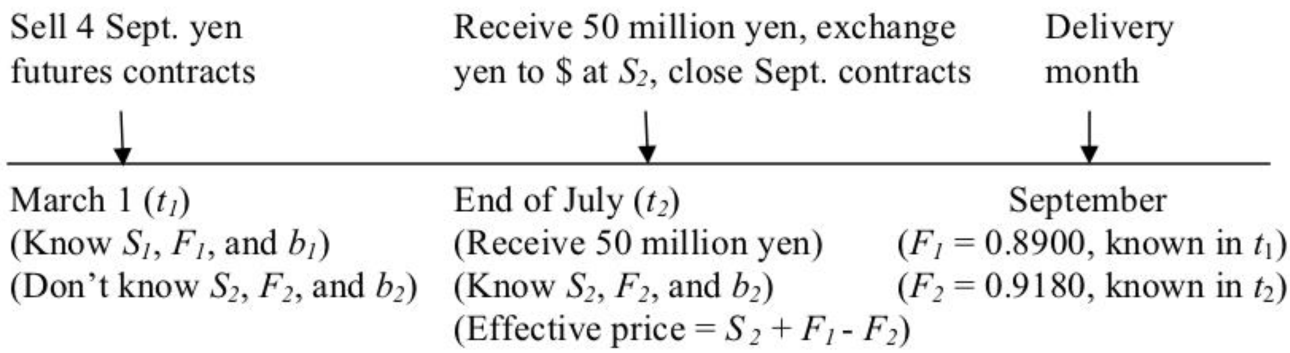
  at the end of July, suppose the spot price was 0.9150 and the September futures price was 0.9180, then the basis $b_2 = 0.9150 - 0.9180 = - 0.0030$

  Gain on futures contract $F_1 - F_2$ $= 0.8900 - 0.9180 = -0.0280$

  Effective price $F_1 + b_2$ $= 0.8900 - 0.0030 = 0.8870$ or

  Effective price $S_2 + F_1 - F_2$ $= 0.9150 - 0.0280 = 0.8870$

- **Detailed Illustration:**



➢ **Factors that increase the basis are:**

- Interest costs, storage costs, positive handling and transportation costs between the location and the futures delivery point
- Positive convexity correction as for Eurodollar futures. The convexity is positive in the case of negative correlation between the underlying of the futures contract and the interest rates.
- Positive quanto correction, in the case of positive correlation between the Foreign exchange rate used to compute the value of the underlying of the futures and the underlying of the futures itself.

➢ **While factors that decreases the basis are:**

- Shortage of local supply on the spot market
- Positive dividends paid by the underlying asset of the futures contract
- Known positive cash flows generated by the underlying asset of the futures contract

❖ SINGLE STOCK FUTURES AND STOCK INDEX FUTURES

- Stock index futures were introduced in the U.S.A. in 1982 with the Commodity Futures Trading Commission (CFTC) approving the Kansas Board of Trade (KCBT) proposal.
- Interestingly, the approval came only 4 years after application, this resulted in the beginning of trading in the Kansas City Value Line index futures.
- After this, stock index futures contracts started on other indices at a number of exchanges both inside and outside the U.S.A.
- In India, the beginning ul the financial futures were made with the introduction of stock index futures by the National Stock Exchange of India Limited (NSE) and The Stock Exchange, Mumbai, in June 2000.
- A distinct and peculiar characteristic of the stock index futures contracts is the nature of the underlying asset—the stock index that traders promise to buy and deliver.
- One can easily visualize that the commodities like wheat, cotton, rice, or metal like gold and, silver may be held and delivered, but it is not clear how someone can "buy" or "sell" a stock index like the Sensex!
- A stock index is just a mathematical formula used for measuring stock price changes. It is interesting to see how it can be traded as well.
- The futures market in India has opened up with the introduction of stock index futures.
- To understand these, as a first step, let us get an idea of the index numbers, see how equity index numbers are constructed and then have a brief account of the major indices available on the Indian capital market scene.

➢ Index Construction

- For a proper understanding about the futures on indices, it is necessary to have an idea about the stock indices.
- An index number is a statistical tool by which relative changes in some variable or a group of variables are measured and expressed, usually, in the percentage form.
- To illustrate, if a share closes at a price of Rs 50 on one day and at Rs 52 the next day, then it has registered an increase of 4 percent (Rs 2 on Rs 50) in a day.
- We can express this information like this: if the closing price of the share on the first day is 100, then the next day's price would be quoted at 104.
- Here day 1 is the base period and day 2 is the current period.
- For day 2, the price index is stated to be 104.
- The index for the base period is usually taken to be 100.
- To continue with the example, if the price of the share quotes at Rs 47 on the third day, the index for the day would be 94 since price of day 3 in relation to the price of the day 1 is (47/50) x 100 = 94.
- The idea of price index can be extended to a group of shares as well.
- But when multiple shares are involved, their prices are usually considered along with their respective numbers outstanding (which serve as the weights of those shares so that each scrip will influence the -- index in proportion to its respective market importance).
- For this a certain base period, normally a year (or may be a certain day of a year) is chosen in the first instance and the average market value of the shares of those companies for this base period is obtained.
- Similarly, the current market value for each scrip is obtained by multiplying the price of the share by the number of shares outstanding.
- The index on a given day is calculated as the percentage of the aggregate market value of the same set of companies, as are included in the base period calculation.

- An index number obtained in such a manner has the flexibility to adjust for the price changes caused by several corporate actions like bonus issues, rights issues etc.
- For example, when a company issues bonus shares, the new weighing factor would be the number of equity shares outstanding after the bonus issue has been made.
- This new weighing factor would be used while computing the index from the date when the change becomes effective.
- Similarly, when a company makes a rights issue, its weighing factor will be increased by the number of additional shares issued.
- A proportionate change is then affected in the base year average. This is done as follows:

  New Base Year Average = Old Base Year Average x $\frac{\text{New Market Value}}{\text{Old Market Value}}$

- To illustrate, suppose a company makes a rights issue which increases the market value of the shares of that company by, say Rs 50 crores. The existing Base Year Average, suppose, is Rs 2680 crores and the aggregate market value of all the shares included in the index before the rights issue is made is, say, Rs 5264 crores. The New Base Year Average would then be obtained as follows:

  New Base Year Average = $\frac{2680 \times (5264 + 50)}{5264}$

  = Rs 2705.45 crores

- This revised base year average of Rs 2705.46 would be used for calculating the index number until a next revision is necessitated.

➢ Major Indices in the Indian Capital Market

1) BSE Sensitive Index Number of Equity Prices, BSE-30: SENSEX

- This is the most widely used and accepted equity price index in the country.
- With the base year to be 1978-79, it comprises of 30 scrips from the specified and non-specified categories of listed companies on The Stock Exchange, Mumbai. Popularly known as sensex, the index has been serving in a large measure, the purpose of quantifying the price movements as also the sensitivity of the market in an effective manner.
- The compilation of the index values is based on the weighted aggregative method.
- The sensex is calculated every minute and displayed continuously during trading hours.

2) BSE National Index of Equity Prices

- After the introduction of sensex in January 1986, another index was launched in January 1989 in the form of BSE National Index of Equity Prices with the base year as 1983-84, comprising of 100 scrips from the specified and non-specified categories of listed companies on the country's five major Stock Exchanges at Mumbai, Kolkata, Delhi, Ahmedabad and Chennai.
- In addition to being a relatively broad-based index, this index enabled the assessment of stock price movements on a national level.
- However, since October 1996, the prices of The Stock Exchange, Mumbai, only are taken in to account for calculation of the index, which is now designated as the BSE Index.

3) BSE-200 and the Dollex

- With the number of companies listed on The Stock Exchange, Mumbai having registered phenomenal growth from 992 in the year 1980 to about 3200 by the end of March 1994 and their combined market capitalization having grown from Rs 5421 crores to Rs 368,070 crores during the period, need was felt to have a more broad-based index which could reflect price changes in a sufficient manner.
- Accordingly, a new index series was introduced in May 1994 with the title BSE-200.
- Also introduced wits the dollar-linked version of the BSE 200 the Dollex, where the formula for calculating BSE 200 is adjusted for-movement of rupee-dollar conversion rates.
- For construction of this index, equity shares of 200 companies, selected on the basis of their market capitalization and other factors from the specified and non-specified categories of listed companies on The Stock Exchange, Mumbai, are included.
- The index is constructed taking the year 1989-90 as the base.
- The index is constructed on the weighted aggregative basis, with the number of equity shares outstanding as weights.
- On a given day, the index is calculated as the percentage of the aggregate market value of the equity shares of all the companies (in the sample) on that day to the average market value of those companies during the base period.

4) BSE 500

- The BSE 500 Index is a broad-based index comprising of 500 scrips chosen from among top 750 companies listed on The Stock Exchange, Mumbai, in terms of market capitalization.
- The index is very broad-based covering all the 23 major industries and 102 sub-sectors of the economy.

- The index has the base dale fixed at February 01, 190 and has the base value set at 1000.

5) NSE-50: S&P CNX NIFTY

- The NSE-50 index was launched by the National Stock Exchange of India Limited, taking as base the closing prices of November 3, 1995 when one year of operations of its Capital Market segment were completed.
- It was subsequently renamed S&P CNX Nifty—with S&P indicating endorsement of the index by Standard and Poor's and CNX standing for CRISIL NSE Index.
- According to the NSE, the index was introduced with the objectives of:
  i. reflecting market movement more accurately,
  ii. providing fund managers with a tool for measuring portfolio returns via-a-vis market returns, and
  iii. providing a basis for introducing index-based derivatives.

❖ Valuation of Stock Index Futures

- A stock index traces the changes in the value of a hypothetical portfolio of stocks.
- The value of a futures contract on a stock index may be obtained by using the cost of carry model.
- For such contracts, the spot price is the "spot index value", the carry cost represents the interest on the value of stock underlying the index, while the "carry return" is the value of the dividends receivable between the day of valuation and the delivery date.
- Accordingly, indices are thought of as securities that pay dividends, and the futures contracts valued accordingly.

- **Case 1:** When the securities included in the index are not expected to pay any dividends during the life of the contract: Here we have,

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

- where F is the value of futures contract, S_0 is the spot value of index, r is the continuously compounded risk-free rate of return, and t is the time to maturity (in years).

- **Example:**

  Calculate the value of a futures contract using the following data:
  Spot value of index = 3090
  Time to expiration = 76 days
  Contract multiplier = 100
  Risk-free rate of return = 8% p.a.

From the given information, we have
Spot value, S_0 = 3090
Time to expiration = 76/365 year
Continuously compounded rate of return = 1n (1.08) = 0.077

Accordingly,

$$\begin{aligned} F &= S_0 e^{rt} \\ &= 3090\ e^{(76/365)(0.077)} \\ &= 3090 * 1.01615 \\ &= 3139.92 \end{aligned}$$

Thus, the value of a contract = 3139.92 x 100 = Rs 3,13,992.

- **Case 2**: When dividend is expected to be paid by one or more of the securities included in the index during ice-life of the contract In the event of dividends expected to be paid on some securities, the dividend amount is discounted to present value terms and then the rule of pricing securities with known income is applied. Thus,

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

- where I is the discounted value of the dividend and other symbols are same as defined earlier.
- The amount of dividend receivable, however, needs a careful consideration, as shown in the example that follows:

- **Example:**

Assume that a market-capitalization weighted index contains only three stocks *A*, *B* and *C* as shown below. The current value of the index is 1056.

Company	*Share Price (Rs)*	*Market Capitalization (Rs crores)*
A	120	12
B	50	30
C	80	24

Calculate the price of a futures contract with expiration in 60 days on this index if it is known that 25 days from today, Company *A* would pay a dividend of Rs 8 per share. Take the risk-free rate of interest to be 15% per annum. Assume the lot size to be 200 units.

We first convert the given rate of interest equal to 15% p.a. into continuously compounded rate of return as follows:

Continuously compounded risk-free rate of return, $r = \ln(1 + 0.15)$

$= 0.1398$

From the given information, it may be seen that Company *A* constitutes 12/66 of the index, which implies that its value in the index is (1056 × 12)/66 = 192. With a price of Rs 120 per share, 192/120 = 1.60 shares of *A* are held for every unit of the index. Accordingly, dividend receivable on 1.60 shares = 1.60 × 8 = Rs 12.80. The present value of dividend *D* = Rs 12.80 may be obtained as under:

Present value of dividend, $I = 12.80e^{-(25/365)(0.1398)}$

$= 12.80 \times 0.9905$

$= 12.68$

Accordingly,

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

$$= (1056 - 12.68)e^{(0.1398)(60/365)}$$

$$= 1043.32 \times 1.0232$$

$$= 1067.53$$

With a lot size of 200, the value of the contract would be Rs 1067.53 × 200 = Rs 2,13,506.

- **Case 3:** When dividend on the securities included in the index is assumed to be paid continuously during the life of the contract. If the dividends may be assumed to be paid continuously, with the dividend yield rata being Y, then the futures price, F, would be given by

$$F = S_0e^{(r - y)t}$$

- **Example:**

Consider a three-month futures contract on NSE-50. Assume that the spot value of the index is 1090, the continuously compounded risk-free rate of return is 12 per cent per annum, and the continuously compounded yield on shares underlying the NSE-50 index is 4 per cent per annum. Find the value of a futures contract, assuming the multiplier to be 200.

Here, $S_0 = 1090$, $r = 0.12$, $y = 0.04$ and $t = 3/12$ or 0.25.

Accordingly,

$$F = 1090e^{(0.12 - 0.04)(0.25)}$$
$$= 1112.02$$

With a multiplier of 200, the value of futures contract is 200 × 1112.02 = Rs 2,22,404.

❖ Uses of Stock Index Futures

- Stock index futures can be used profitably by all market participants including speculators, arbitrageurs and hedgers.
- Speculation In a bid to make money, speculators use index futures to take long or short positions.
- Such positions are taken on the premise that the index would go up or down.
- If the multiple is 100 (which is used to convert the index into monetary "Value"), then each point of index movement would translate into Rs 100.

- If a person is bullish and believes that the market would go up in the time to come, he may buy futures and if he is bearish about the market, he may sell futures contracts.
- He would make money if the market does move as anticipated.
- To illustrate, suppose it is the beginning of the month of August. A speculator believes that the stock market will soon improve on the back of sustained economic recovery, but is not quite sure which. stocks in particular will rise. He decides, therefore, to take position in a one-month futures contract, say BSXAUG (the futures contract on Sensex of The Stock Exchange, Mumbai, expiring in August), that is currently available at 4480. To take an exposure of Rs 30 lac, he needs to buy 7 contracts of 100 lot size with August maturity. He decides to take long position in 7 contracts and pays the required margin, say 10% which equals Rs 3,13,600.
- Now, after two weeks, suppose the contract is trading at 4710. He decides to unwind his position and sell off the contracts. In the process, he makes a profit of (4710 — 4480) x 7 x 100 = Rs 1,61,000 less the transactions costs of taking two positions in futures. But, again, the transactions costs for entering into markets are much lower than in ease of securities. It is clear that substantial gains arc possible (without risk of default) if underlying index moves in the predicted direction.

➢ **Arbitrage:**

- Arbitrageurs play a key role in the financial markets. Unlike speculators, they do not take view on prices but they step in as soon as they discover that there is a mismatch between prices.
- The arbitrageurs thrive on market imperfections and through their actions, they keep the market efficient and well-functioning.
- It may be mentioned that simultaneous buying and selling the same thing in two markets, like buying and selling of shares of a company in two exchanges to take advantage of price differential in them, is called arbitrage over space.

- On the other hand, attempting to make profits through buying/selling in the spot and futures markets is termed as arbitrage over time.
- In arbitrage over time, an arbitrageur can earn returns by lending money or securities in the market.
- There is no counter-party risk and the trading technique involves buying/selling in cash and futures markets.

➢ **Funds Lending:**

- For an arbitrageur willing to employ funds, the methodology involves first buying shares in the cash market and selling index futures.
- The quantity of shares to be bought is decided on the basis of their weightage in the index and the order is put through the system simultaneously using the program trading method.
- At the same time, a sell position is taken in the futures market.
- The position is closed with opposite transactions in cash and futures markets.
- Similarly, an arbitrageur can earn returns by lending securities in the market.
- The methodology involves first selling the shares in the cash market and buying index futures, deploying the cash received in some risk-less investment, and finally, buying the same shares and shorting the futures position at the expiration.
- The quantity of shares to be sold is decided on the basis of their weightage in the index.
- At the same time, a sell position is taken in the futures market Here too, the position is closed with opposite transactions in cash and futures markets-and the shares are received back.

➢ Hedging:

- Hedging is the prime reason for development of futures contracts. Stock index futures can be effectively used for hedging purposes.
- They can be used while taking a long or short position to a stock and for portfolio hedging against unfavorable price movements. This subject is discussed in detail below:

❖ HEDGING USING STOCK INDEX FUTURES CONTRACTS

- Stock index futures contracts can be used to manage investment exposure and control the risk related to movements in equity market in a well-diversified portfolio of stocks through the use of hedging strategies.
- However, to understand what is possible to hedge and what is not, we need to understand the concepts of equity risk including some ideas of portfolio theory and Capital Asset Pricing Model (CAPM), and the market versus non-market risk.
- We begin with the idea that the stock prices fluctuate because of two sets of factors: Systematic and non-systematic.
- Systematic factors are those that influence the market as a whole and include such things as interest rates, taxation policies, political conditions, fiscal and monetary policies etc.
- Non-systematic or company specific factors are those that are peculiar to a particular company and may relate to technological developments, labour-relations, takeover situations etc.
- When an investor takes a long position in a stock, he believes that it is under-valued and hopes to gain when its price increases.
- Any appreciation in its value will yield him profits. But his assessment need not be correct.

- Thus, while taking the long position, he carries the risk of his basic thinking about the stock being wrong. There is another risk he carries, namely the market might move in the unfavorable direction and therefore, the particular stock he bought declines in value.
- While in the first case he is bound to suffer losses, should his judgement about the stock prove incorrect, he is also prone to suffer losses when the whole market moves in the downward direction for whatever reasons, although his analysis of stock was correct.
- Similarly, when an investor takes a short position in a stock, in the belief that the stock is overvalued, any decline in the stock price would earn him profits.
- Here again, the investor runs the twin risks: his analysis and conclusion about the stock being in error and the risk arising from the movement of the entire market in an adverse direction, despite a correct stock pick.
- To conclude, when an investor takes a long (or short) position in a stock, he also carries a long (or short) position to some extent in the index as well.
- The degree of movement in the price of a share of stock with respect to movements in the market, i.e, a stock price index, is measured in terms of beta, $\boldsymbol{\beta}$.
- The beta reflects the sensitivity of the movement of a scrip relative to the Movement of the index.
- For its calculations, the returns on security are regressed over the returns on an index and the regression co-efficient $\boldsymbol{\beta}$ is obtained. Accordingly,

$$\boldsymbol{\beta} = \frac{\boldsymbol{Covariance\ (Stock, Index)}}{\boldsymbol{Variance\ (Index)}}$$

- The covariance and variance are obtained from the returns data of the security and the index. If X and Y be the returns on index and return oil stock respectively, we have,

$$\boldsymbol{Covariance} = \frac{\boldsymbol{\Sigma(X - \bar{X})(Y - \bar{Y})}}{\boldsymbol{n}}$$

$$\boldsymbol{Variance\ (X)} = \frac{\boldsymbol{\Sigma(X - \bar{X})^2}}{\boldsymbol{n}}$$

- in which $\boldsymbol{\bar{X}}$ is the mean value of X series and $\boldsymbol{\bar{Y}}$ is the Mean value of the Y series.

- Alternatively,

$$\beta = \frac{\Sigma XY - n\bar{X}\bar{Y})}{\Sigma X^2 - n\bar{X}^2}$$

- **Example:**

For a given share, the prices are observed for 13 days and are recorded below along with the index values on those days.

You are required to regress the returns on the share on the returns on the index. What does the beta, the regression coefficient, indicate?

Day	*Share Price Index*	*Price of Share*	*Day*	*Share Price Index*	*Price of Share*
1	1376.15	818.35	8	1447.55	792.30
2	1388.75	811.75	9	1439.70	778.30
3	1408.85	819.85	10	1427.65	740.95
4	1418.00	836.05	11	1398.25	718.35
5	1442.85	815.65	12	1401.40	737.50
6	1445.15	804.30	13	1419.70	735.55
7	1438.65	801.30			

The returns on the index and the security are given in the first two columns of the Table 3.1, headed X and Y respectively. The values of X and Y are calculated as follows:

$(1388.75 - 1376.15)/1376.15 = 0.009156$ or 0.9156 percent

$(1408.85 - 1388.75)/1388.75 = 0.014473$ or 1.4473 percent etc.

$(811.75 - 818.35)/818.35 = - 0.008065$ or $- 0.8065$ percent

$(819.85 - 811.75)/811.75 = 0.009978$ or 0.9978 percent etc.

Note that the values of X and Y are given in percentages.

The mean values of X and Y series are:

$$\bar{X} = \frac{3.1857}{12} \cong 0.2655$$

$$\bar{Y} = \frac{-10.3751}{12} = - 0.8646$$

Table 3.1 *Calculation of Share Beta*

Day	Index	Share Price	Index Returns X	Share Returns Y	XY	X^2
1	1376.15	818.35				
2	1388.75	811.75	0.9156	− 0.8065	− 0.738430	0.838319
3	1408.85	819.85	1.4473	0.9978	1.444224	2.094807
4	1418.00	836.05	0.6495	1.9760	1.283326	0.421806
5	1442.85	815.65	1.7525	− 2.4400	− 4.276102	3.071145
6	1445.15	804.30	0.1594	− 1.3915	− 0.221819	0.025411
7	1438.65	801.30	− 0.4498	− 0.3730	0.167766	0.202302
8	1447.55	792.30	0.6186	− 1.1232	− 0.694836	0.382710
9	1439.70	778.30	− 0.5423	− 1.7670	0.958240	0.294085
10	1427.65	740.95	− 0.8370	− 4.7989	4.016600	0.700535
11	1398.25	718.35	− 2.0593	− 3.0501	6.281236	4.240833
12	1401.40	737.50	0.2253	2.6658	0.600563	0.050752
13	1419.70	735.55	1.3058	− 0.2644	− 0.345272	1.705210
		Total	3.1857	− 10.3751	8.475496	14.027915

$$\beta = \frac{\Sigma XY - n\overline{X}\overline{Y}}{\Sigma X^2 - n\overline{X}^2}$$

$$\beta = \frac{8.475496 - 12 \times 0.2655 \times (-0.8646)^2}{14.027915 - 12 \times 0.2655^2}$$

$$= 0.8519$$

- **Interpretation of Beta of a Security**

- The bench-mark, the index beta, is equal to 1.0.
- If a stock has β > 1, it is riskier than the market. To be precise, if 1.25 for a given stock then-it implies that if the market-increases by 10 percent, its value will increase by 12.5 percent, while if the market falls by 10 percent, the value of the stock would fall by 12.5 percent.
- On the other hand, if a stock has β = 0.92, then a 1 percent rise in the stock price index would lead to 0.92 percent rise in the stock value and a 1 percent fall in the index value would imply a 0.92 percent fall in the stock value.

- The regression coefficient 0.8519 calculated in the example above can be similarly interpreted.
- Further, a stock with β = 1 obviously moves "with the market".
- High beta shares are, naturally, preferable in the bullish markets while low beta shares are "safe" securities – advantageous in times of bearish market conditions.
- The beta values for the stocks included in the Sensex for the period June, 2000 to May 2001 are shown in Box 3.6.:

Box 3.6 ***Beta Values for the Sensex Securities***

S. No.	Security	Beta	S. No.	Security	Beta
1.	ACC	1.13	16.	INFOSYS TECH	1.78
2.	BAJAJ AUTO	0.32	17.	ITC LTD	0.54
3.	BHEL	1.08	18.	LARSEN & TOU	1.07
4.	BSES LTD	0.79	19.	MAH & MAH	1.02
5.	CASTROL IND	0.52	20.	MAHANGR TELE	0.95
6.	CIPLA LTD	0.73	21.	NESTLE LTD	0.34
7.	COLGATE	0.32	22.	NIIT LTD	1.59
8.	DR. REDDY'S LAB	0.65	23.	RANBAXY LAB	0.80
9.	GALAXO (I) LTD	0.55	24.	REL PETROL	0.94
10.	GRASIM IND	0.88	25.	RELIANCE	0.88
11.	GUJ AMB CEMENT	0.60	26.	SATYAM COMP	2.39
12.	HIND LEVERL	0.61	27.	STATE BANK	0.85
13.	HIND PETROL	0.63	28.	TATA ENGG	1.06
14.	HINDALCO	0.31	29.	TATA STEEL	1.15
15.	ICICI LTD	0.97	30.	ZEE TELEFILM	2.18

Source: *The Stock Exchange, Mumbai*

- In terms of the discussion in the preceding paragraphs, we may restate the ideas in a more formal way as follows.
- The total risk of a stock, which is usually measured by the variance (or standard deviation) of the distribution of its returns, can be divided into two components: systematic risk and non-systematic risk.

- The systematic risk is also called the market risk, and it results from the systematic factors while the non-systematic risk or specific risk stems from factors peculiar to a company or industry. The two components of risk may be described as follows:
- Consider the market model:

$$k_j = \alpha_j + \beta_j k_m + e_j$$

- It states that the returns on security **j** are a linear function of the returns on the market portfolio (which may be, for example, SENSEX, NSE-50 etc.). The $\mathbf{e_j}$ is the 'error term' and is the deviation of a return from its predicted value.
- We may restate the above equation as follows:

$$e_j = k_j - [\hat{\alpha} + \hat{\beta} k_m]$$

- The term in the brackets gives the estimated or predicted value by using the estimated regression coefficients $\hat{\alpha}$ and $\hat{\beta}$, and a given value of the market return.
- The error term is caused by the firm **j**'s non-systematic risk.
- Further, β (beta) here is a measure of the sensitivity to market movements so that the greater the beta of a security, the more sensitive would it be any market moves.
- The CAPM lays that the investors expect to earn greater returns as beta increases, as it is stipulated that

$$(Expected)k_j = k_f + [(Expected)k_m - k_f]\beta_j$$

- In words, it means that the expected return on an investment-in a security equals the risk-free rate (k_f) plus beta times the excess of expected return on market portfolio over the risk-free rate.
- Now, to see that total risk is composed of systematic and non-systematic risk, we take the variances of both sides of the market model equation given earlier, to get

$$var\ (k_j) = var\ (\alpha_j + \beta_j k_m + e_j)$$

Or, $$var\ (k_j) = \beta_j^{\ 2}\ var\ (k_m) + var\ (e_j) + 2\beta_j cov(k_m, e_j)$$

- (because α and β are constants while $\mathbf{k_j}$, $\mathbf{k_m}$ and $\mathbf{e_j}$ random-variables)
- If the covariance of market returns and error terms zero, then we have

$$var(k_j) = \beta_j^{\ 2}\ var\ (k_m) + var\ (e_j)$$

$$Total\ Risk = Systematic\ or\ Market\ Risk + NonSystematic\ or\ NonMarket\ Risk$$

- Given the beta of a security, the variance of its returns, and the variance of the market returns, we can split the total risk into systematic and unsystematic components.

❖ Need of Hedging and the Hedging Process

- Before proceeding further, let us understand why at all hedging may be needed. Hedging can as much be the need of an investor holding one or more stocks, as of a mutual fund.
- Consider a portfolio manager who has a portfolio of Rs 100 crores held primarily in equity shares.
- Suppose that he anticipates a decline in the market in the near future.
- To avoid writing a low portfolio value, he might decide to sell the securities of the portfolio and again invest when the prices fall, thereby protecting his gains.
- However, it would be very expensive in terms of the commissions, taxes and other costs involved in such a big deal.
- The alternative is provided by the stock index futures contracts—taking an offsetting position in them.
- Thus, long position in the stock market would be accompanied by short position in the futures markets.
- Calculations need to be done to determine the number of contracts to counteract the likely changes in the portfolio value.
- Before we consider how stock index futures can be used for hedging purposes, it should be noted that the use of index futures controls only the market risk component of the total risk and not tote non-market, or unsystematic risk.
- Thus, a cent percent protection should not be expected from such hedging.
- Another thing to be kept in mind is that hedging is not intended to make profit but rather only as a protection against adverse price movements.
- Any `over-hedging' (by taking a position bigger than is warranted) implies that the investor is engaging in speculation.
- **Example:**

  Suppose that the variance of daily returns of a security with $\boldsymbol{\beta}$ = 1.2, is 8.2. Further, the standard deviation of daily returns of an index is 1.7. Calculate the magnitude of risk reduction which a complete hedging will achieve and the risk faced by the investor with hedging.

Here, Total risk, var $(k_j) = 8.2$

Market risk, $\beta_j^2 \text{ var } (k_j) = (1.2)^2 (1.7)^2 = 4.1616$

Thus, risk reduction by hedging = 4.1616, and risk faced by investor, non-market risk = 8.2 – 4.1616 = 4.0384.

- We first consider hedging through stock index futures as a long position risk management tool. It is followed by use of stock index futures in relation to portfolio management. In this context, we consider how such futures -can. be used for adjusting the beta of a portfolio, and then a complete hedge of the portfolio.

❖ Long Position Risk Management

- An investor takes a long position in a stock in the expectation that it is undervalued and likely to appreciate.
- In taking this position, he carries not only the risk of his estimate of the stock being wrong but also, he faces the risk of the market moving against his thinking.
- He can hedge against this latter risk by taking a short position in stock index futures contracts.
- If the index does fall, he loses the value of the stock held but he gains on the position taken in futures.
- To determine the value of futures contracts to take position in, the beta of the stock in question is required.
- Thus, if the stock beta is 1.3, then for hedging a long position of Rs 20 lac worth of shares, one has to take a short position in futures to the extent of Rs 20 lac x 1.3 = Rs 26 lac.
- Similarly, a short position in futures for Rs 16 lac is needed for covering a Rs 20 lac long position in a stock with beta equal to 0.8.

- To illustrate the risk management in case of long position on stock, assume that an investor buys 2000 shares of a company at a price of Rs 500 per share on September 14, on analysis of company future prospects.
- On this day, the stock price index, say Sensex, is ruling at 4480.

- Three weeks after he buys shares, on October 4, the company declares half-yearly results which cause the share price to rise to a level of Rs 534.
- But almost at the same time he fears that due to a decision of the OPEC members, the oil prices are likely to increase sharply, causing hardships to the world economies.
- The stock markets are likely to be adversely affected by their action.
- To hedge against the likely fall in the index, he needs to take a short position in index futures.
- The portfolio value on October being 534 x 2000 = Rs 10,68000 for which protection is required.
- The investor learns that the analysis of the last three months' data reveals that this stock price, when regressed over Sensex, has beta equal to 1.2.
- Accordingly, the short position required for coveting Rs 10,68,000 portfolio is worth Rs 10,68,000 x 1.2 = Rs 12,81,600.
- Assuming the October futures is trading at 4520, he would short 1281600/4520 -= 283.5 Or 300 (assuming the market lot is 100) contracts.
- At the maturity of the October futures if the index closes at, say 4130 and the price of the share in question be, say Rs 478, then the position may be analyzed as follows:

Loss in the value of portfolio	(534 - 478) x 2000 = Rs 112,000
Gain in futures contracts	(4520 - 4130) x 300 = Rs 1,17,000

- Thus, the investor makes a marginal gain of Rs 5,000 on the deal. It will be reduced, of course, by the amount of transactions costs incurred by him.
- It may be noted that the hedge is available to the investor only until the maturity of the futures contracts and not afterwards.
- In case, he still fears a further decline in the market prices, he needs to take fresh position.
- In the first instance, if the investor had a feeling that changes might take place lasting the next two months, he would do well to take position in 2-month futures.

❖ Short Position Risk Management

- Investors take short positions in individual stocks when they think that the stocks are overvalued and that decline in them will give them profits.
- However, while taking a short position in a stock, m investor also carries the risk of his basic thinking about the stock being incorrect and the risk of the market moving against his prediction.
- This risk of market increase can be sorted out by simply buying some amount of index futures.
- In this way, he hedges his index movement risk and minimizes his total risk.

- To illustrate, suppose that an investor is short 1000 shares at Rs 690 and the beta of the stock is 0.9, then the investor should hedge by taking a long position in the near-month stock index futures for 690 x 1000 x 0.9 = Rs 621,000.
- If the one-month index contracts are trading at 3620, then the investor would sell 621000/3620 = 171.5 or 200 contracts (if the market lot is 100 contracts).
- By the expiry of this contract, suppose the market recovers and the index becomes 4280 and the price of the underlying share becomes Rs 761.
- In this case, the investor's position can be analyzed as follows:

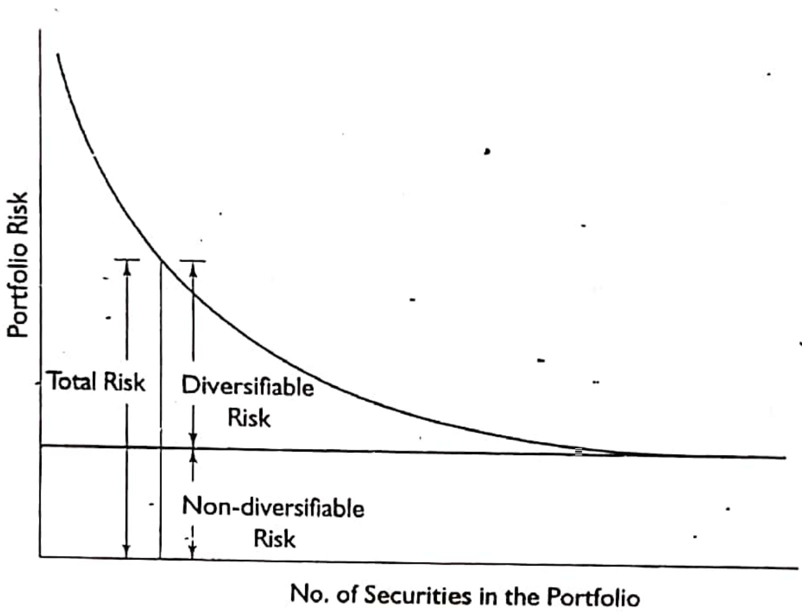
Loss on position in share	(761 - 690) x 1000 = Rs 71,000
Gain on futures contracts	(4280 - 3620) x 200 = Rs 1,32,000

- Thus, the investor is immunized against market movements by taking position in index futures.

❖ Portfolio Risk and Portfolio Beta

- Like for an individual security, the total risk of a portfolio of securities can also be decomposed as systematic risk and non-systematic risk.
- The total risk is a function of the number of securities in a portfolio.

- Non-systematic risk is diversifiable in nature so that it can be reduced in a portfolio by increasing the breadth (that is to say, by increasing the number of securities) of the portfolio.
- In fact, a principal result of the capitol market theory is the fact that the investors are not rewarded for bearing unsystematic risk.
- The market assumes that the investor has reduced the risk through diversification as much as possible, for a given level of expected return.
- On the other hand, the systematic risk is not diversifiable by adding securities to the portfolio.
- As depicted in below figure, the total risk declines with an increase in the number of securities in the portfolio until it reaches a limit, beyond which it does not decline.



- We shall see shortly that the systematic risk can be reduced in a portfolio by hedging with index products.
- It has been said earlier that beta of a security measures its sensitivity to market movements.
- Specifically, it means, for example, that a security with a beta of 1.5 will, on an average, move 1.5 times, or 1.5 percent for each 1 percent move in the market.
- Similarly, a beta of 1 would indicate a stock that fluctuates in line with the underlying market, while a beta factor of 0.75 would indicate a stock which fluctuates 0.75 percent for every 1 percent market move. (The beta factors of various equities are obtainable from leading data bases.)

- Using beta factors of equities consisting a portfolio, it is possible to work out a weighted arithmetic mean beta factor for the portfolio itself. In symbols,

$$\boldsymbol{\beta_p = w_1\beta_1 + w_2\beta_2 + \cdots + w_n\beta_n}$$

- Wherein $\boldsymbol{w_1, w_2, \dots w_n}$ is the fraction of total investment placed in the respective securities, and $\boldsymbol{\beta_1, \beta_2 \dots \beta_n}$ are their corresponding beta factors.
- Example:

A portfolio manager owns three securities, as detailed below:

Security	*No. of Shares*	*Price per Share (Rs)*	*Beta*
1	15,000	40	1.2
2	25,000	20	1.8
3	15,000	60	0.8

The beta value for this portfolio can be obtained as shown in Table 3.2.

Table 3.2

Calculation of Portfolio Beta

Security	*Value (in lacs of Rs)*	*Weight (w_i)*	β_i	$\beta_i w_i$
1	6	6/20 = 0.30	1.2	0.36
2	5	5/20 = 0.25	1.8	0.45
3	9	9/20 = 0.45	0.8	0.36
Total	20			1.17

- The value for each security is the product of the number of shares and the price per share.
- The weightage of each security is obtained by dividing its value by the total value of the portfolio.
- The summation of the products of the beta values and the weightage of the securities works out to be 1.17, which is the beta value of the given portfolio.
- Obviously, if the portfolio beta is greater than 1, as in this case, then in a rising market, the portfolio would rise faster than the market and, so, expectedly outperform the market.
- On the other hand, a portfolio with a low beta will not lose as much value as the market average and the losses will be considerably lower than for a portfolio with a high beta.

- It is thus possible to tune the beta of a portfolio either when a greater perfect hedge is sought or an improvement in performance is considered when a strong market view is perceived.
- Naturally, risky-portfolios fluctuate more than the market average and thus need a greater hedge, while low-beta portfolios, being conservative, need a smaller hedge.

❖ Adjusting the Beta of a Portfolio Using Stock Index Futures

As mentioned above, portfolio managers would adjust their portfolio betas in keeping with the changes in the risk and return offered by the stock market. Thus, when they believe that the stock market offers a relatively high expected return, for a given level of risk, they would increase the beta values of their portfolio, and, on the other hand, when they turn more bearish or feel that the market risk has increased, they would tend to lower their portfolio betas.

The changes in the portfolio beta can be effected by selling or buying part of the portfolio and substituting them by risk-less securities. Also, instead of buying/selling and substituting the securities which may involve significant transactions cost, the manager can bring about the desired changes by buying or selling index futures contracts instead.

Reconsider the example above. The manager has a portfolio of Rs 20 lacs, with a beta value of 1.17. Suppose now that the spot index is at 1120 and the futures price is 1125. Further, the futures contract has a multiple of 50. We may now see as to how to use stock index futures to, say, (a) decrease the portfolio beta to 0.9, and (b) increase the portfolio beta to 1.5.

(a) To decrease the portfolio beta from 1.17 to 0.9, the portfolio manager may sell off a portion of equities and use the proceeds to buy risk-less securities. If we let the existing portfolio as asset 1 and the risk-less security as asset 2, we have,

$$\beta_p = w_1\beta_1 + w_2\beta_2$$

$$= w_1\beta_1 + (1 - w_1)\beta_2$$

(since the new portfolio consists of only two assets)

We have, $\beta_p = 0.9$ (the desired portfolio beta), $\beta_1 = 1.17$ (the beta value of the existing portfolio or asset 1), and $\beta_2 = 0$ (this being a risk-less asset). Substituting the known values, we get

$$0.9 = w_1 \times 1.17 + (1 - w_1)0$$

or, $$w_1 = 0.76923$$

This implies that a portfolio consisting of Rs 15.3846 lacs, 0.76923 times Rs 20 lacs, invested in three securities as given above and Rs 20 (lacs) – Rs 15.3846 (lacs) = Rs 4.6154 lacs in risk-less securities (Treasury Bills) would have a beta of 0.9.

Alternatively, the manager can sell stock index futures contracts. We have seen earlier that the number of futures contracts to trade in order to have a risk-minimizing hedge can be obtained as under:

Number of Futures Contracts to Trade =

$$h \times \left(\frac{\text{No. of Units of Spot Position Requiring Hedging}}{\text{No. of Units Underlying One Futures Contract}} \right)$$

Here, we may use beta of the portfolio to serve as h^*, and take the ratio of the monetary value (Rupee value) of the spot position to be hedged, and the monetary value of the spot index. For our example,

$$h^* = 1.17$$

Rupee value of the Spot Position to be Hedged = Rs 4.6154 lacs

Rupee value of one Futures Contract = Index Value × Multiplier

= 1120 × 50 = Rs 56,000

= Rs 0.56 lacs

Number of Futures Contracts required to change Portfolio Beta from 1.17 to 0.9 = 1.17 × 4.6154/0.56 = 9.643

Alternatively, the calculation can be done as under:

Number of Futures Contracts required to be Sold =

$$\frac{P(\beta_p - \beta'_p)}{F}$$

where P refers to the value of the given portfolio

β_p is the value of the beta of the portfolio

β'_p is the desired value of beta

F is the value of a futures contract

We have $P =$ Rs 20 lacs, $\beta_p = 1.17$ $\beta'_p = 0.9$, and $F = 1120 \times 50 =$ Rs 0.56 lacs. With these values, we get

Number of Futures Contracts required to be Sold =

$$\frac{20 \times (1.17 - 0.9)}{0.56} = 9.643$$

Thus, instead of selling Rs 4.6154 lacs of the risky equity portfolio, the manager can reduce the beta to 0.9 by selling 9.643 (or 10) stock index futures. The manager may, therefore, continue to own the Rs 20 lacs equity stock portfolio by selling the required number of futures to hedge Rs 5.40 lacs of that portfolio.

(b) Now, to increase the portfolio beta from 1.17 to 1.50, we proceed as follows:

We have, $\beta_p = w_1\beta_1 + (1 - w_1)\beta_2$

or $1.5 = w_1 \times 1.17 + (1 - w_1)0$

or $w_1 = 1.28205$

This implies shorting the risk-less asset Treasury Bills with a market value of $0.28205 \times 20 =$ Rs 5.641 lacs, so that the total investment in the portfolio of three-securities be Rs 25.641 lacs and Rs 5.641 lacs is borrowed.

The aim of increasing beta to 1.5 can be achieved alternately by buying stock index futures contracts equivalent to Rs 5.641 lacs. The required number of contracts can be determined as follows:

- Number of Futures Contracts required to change Portfolio Beta from 1.17 to 1.50 = $1.17 \times 5.641/0.56 = 11.786$.

The same answer can be obtained using the alternative approach given earlier. Accordingly, with $P =$ Rs 20 lacks, $\beta_p = 1.17$, $\beta'_p = 1.50$, and $F = 1120 \times 50 =$ Rs 0.56 lacs, the required number of contracts would be equal to

$$\frac{20 \times (1.50 - 1.17)}{0.56} = 11.786$$

Note that in the numerator, the difference between the actual and desired portfolio beta values is needed, which was taken to be $\beta_p - \beta'_p$ in the first case and $\beta'_p - \beta_p$ in the second case. In fact, we should subtract the smaller value from the larger value in a given situation.

In any case, the hedger should buy 11.786 or 12 contracts in this situation.

Adjusting the Portfolio β to Zero: A Complete Hedge

We have seen how futures contracts can be used for tuning the beta of a given portfolio in keeping with expectations about market movements. However, if the market is expected to decline, then while a reduction in the beta is beneficial, it does not completely protect the investor. A full protection calls for adjusting the beta value equal to zero. Obviously, if beta value is set equal to zero, then a given portfolio is immune to market changes. Thus, a complete hedge may be achieved by shorting futures contracts as follows:

No. of Futures Contracts to Sell

$$= \frac{\text{Value of spot position requiring hedging}}{\text{Value of a futures contract}} \times \text{Portfolio beta}$$

The above given formula is employed if cent percent of the portfolio is to be hedged. If higher or lower than 100% portfolio value is required to be hedged then the above expression is multiplied by the such percentage value. Thus, in the above case, if it is desired to hedge 80 percent of the portfolio, the number of contracts to short would be 80% of the number determined.

To illustrate complete hedging, suppose that an investor has a portfolio of Rs 34 lakhs, comprising of five securities. The portfolio has beta equal to 0.94. The investor is thinking of hedging using November SENSEX futures. He finds that presently, on September 5, the SENSEX is trading at 4930 and the November expiry futures are trading at 4972. Accordingly, the value of a futures contract (assuming the multiple is 100) is Rs 100 × 4972 = Rs 497,200. Now, the investor has to short (3400,000/497,200) × 0.94 = 6.43 or 7 contracts. Thus, his sell value is Rs 34,80,400.

We now consider the consequences of different market scenarios at the final delivery of the contract.

(a) The market declines If the market declines as anticipated by the investor, he would stand to lose on the stock portfolio but would gain in the futures market. Suppose the SENSEX falls from 4930 to 4512. This is a decline of 8.48 percent in the index. The portfolio value would have, therefore, declined by 8.48 × 0.94 or 7.9712% or Rs 271,000 (approximately). In the futures market, he would gain. He would close the 7 contracts sold by buying as many contracts at 4512 (since at maturity, the price of the futures contract matches with the index). Thus, the gain to the investor in this market would be 460 × Rs 100 × 7 contracts = Rs 322,000. The net position is a gain of 322,000 – 271,000 = Rs 51,000.

(b) The market rises Now, assume that the market does not move the way the investor thought and instead, rises, with SENSEX scaling to 5480. This increase of 550 points, or 11.16 percent results in a gain in the portfolio value by 11.16 × 0.94 = 10.49 percent or 3400,000 × 10.49% = Rs 356,660. However, the investor incurs a loss in the futures market, amounting to 7 × 100 × (5480 – 4972) = Rs 355,600. The combined position in the cash and futures markets means a net gain of 356,660 – 355,600 = Rs 1060.

(c) The market is unchanged In the third possible scenario, suppose the SENSEX remains unchanged at 4930. This would cause the value of the portfolio remain at Rs 3400,000. However, in the futures market he would make a gain of (4972 – 4930) × 100 × 7 =Rs 29,400. Thus, the investor gains Rs 29,400 in the process.

Note, however, that in each of the three situations discussed above, we have not considered the costs like commissions etc. But, the costs of taking positions are relatively very low in comparison to the cash markets.

Example 3.7

On January 1, 2002, an investor has portfolio consisting of eight securities as shown below:

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

The cost of capital for the investor is given to be 20% per annum. The investor fears a fall in the prices of the shares in the near future. Accordingly, he approaches you for advice.

You are required to:

(a) state the options available to the investor to protect his portfolio.

(b) calculate the beta of his portfolio.

(c) calculate the theoretical value of the futures contracts according the investor for contracts expiring in (1) February, (2) March.

(d) calculate the number of units of S&P CNX Nifty that he would have to sell if he desires to hedge until March (1) his total portfolio, (2) 90% of his portfolio and (3) 120% of his portfolio.

(e) determine the number of futures contracts the investor should trade if he desires to reduce the beta of his portfolio to 0.9.

You can make use of the following information/assumptions:

(i) The current S&P CNX Nifty value is 986.

(ii) S&P CNX Nifty futures can be traded in units of 200 only.

(iii) The February Futures are currently quoted at 1010 and the March Futures are being quoted at 1019.

(a) There are two options for the investor to protect his portfolio:

(1) to sell the shares now and repurchase them later when they are cheaper.

(2) to sell the NIFTY futures contracts and keep the portfolio intact.

Option 1 is likely to be costlier since the selling of shares and repurchasing them would require incurring of transaction costs including brokerage charges, stamp duty and payment of service or other taxes, if any. Not only this, he is likely to lose some more amount because of illiquidity in the market. While selling his shares, he might have to quote a price slightly lower than the best bid in an attempt to sell his entire holding. Similarly, while buying shares, he might have to quote a somewhat higher price to procure all his purchases. This is termed as *impact cost*, as indicated earlier.

In this option, the investor would gain if the prices do fall by a margin which exceeds the costs involved in the trading operations. However, if the prices were to actually rise, he would stand to lose.

In option 2, the impact cost and transaction costs are likely to be much lower. Trading in a derivatives market is generally cheaper than trading in a cash market. If the share prices do fall, he would lose on the value of the portfolio but gain on the futures contracts since he would have sold futures at a relatively higher price, while if the share prices go up, he would lose on the futures contracts and gain in terms of the portfolio value. Thus, he is "protected" in option 2.

(b) The portfolio of the investor has a beta value equal to 1.10149 as shown calculated in Table 3.3.

Calculation of Portfolio Beta

Security	*Price of the Share*	*No. of Shares*	*Value*	*Weightage* w_i	*Beta* β_i	$w_i\beta_i$
A	29.40	400	11,760	0.012	0.59	0.00708
B	318.70	800	254,960	0.256	1.32	0.33792
C	660.20	150	99,030	0.100	0.87	0.08700
D	5.20	300	1,560	0.002	0.35	0.00070
E	281.90	400	112,760	0.113	1.16	0.13108
F	275.40	750	206,550	0.208	1.24	0.25792
G	514.60	300	154,380	0.155	1.05	0.16275
H	170.50	900	153,450	0.154	0.76	0.11704
	Total		994,450			1.10149

(c) Calculation of theoretical values of the futures contracts:

It is given that cost of capital = 20% p.a. Accordingly, the continuously compounded rate of interest = ln (1 + 0.20) = 0.18232. For the February contracts, $t = 58/365 = 0.1589$ while for the March contracts, $t = 89/365 = 0.2438$. Further, $F = S_0 e^{rt}$. Thus,

For February contracts, $F = 986e^{(0.18232)\ (0.1589)}$

$= 986 \times 1.02939 = 1014.98$

For March contracts, $F = 986e^{(0.18232)\ (0.2438)}$

$= 986 \times 1.0455 = 1030.32$

(d) Value of a March contract = 1019 × 200 = Rs 203,800

No. of futures contracts required to be sold may be calculated by using the following formula:

No. of contracts

$$= \frac{\text{Value of spot position requiring hedging}}{\text{Value of a futures contract}} \times \text{Portfolio beta}$$

(i) *when total portfolio is to be hedged:*

$$= \frac{\text{Rs } 994{,}450}{\text{Rs } 203{,}800} \times 1.10149$$

= 5.39 or 6 contracts

(ii) *when 90% of the portfolio is to be hedged:*

$$= \frac{\text{Rs } 994{,}450 \times 0.90}{\text{Rs } 203{,}800} \times 1.10149$$

= 4.84 or 5 contracts

(iii) *when 120% of the portfolio is to be hedged:*

$$= \frac{\text{Rs } 994{,}450 \times 1.20}{\text{Rs } 203{,}800} \times 1.10149$$

$$= 6.45 \text{ or } 7 \text{ contracts}$$

(e) For calculating the number of futures contracts required to be sold to lower the beta to 0.7, we have
value of the portfolio, P= Rs 994,450
current beta of the portfolio, β_p= 1.10149
desired beta value, β'_p = 0.7, and
value of a futures contract = 986 × 200 = Rs 197,200

$$\text{Now, No. of contracts to sell} = \frac{P(\beta_p - \beta'_p)}{F}$$

$$= \frac{994{,}450\,(1.10149 - 0.7)}{197{,}200}$$

$$= 2.02 \text{ or } 2 \text{ contracts}$$

FUTURES ON STOCKS

Like futures on commodities, futures contracts on shares of individual stocks of companies are also traded in some countries including Australia, England, Hong-Kong, India, Sweden etc. In such contracts, the underlying happens to be a certain number of shares of a particular company. In general, futures on individual stocks are unimportant in the world trading markets and they have not been very successful. However, in India the introduction such contracts in November 2001 has met with a good reception from the market participants, to begin with.

A futures contract on a stock is one where the party with long position agrees to buy a certain number of shares of a company at a certain price at a certain date in future and the party with short position agrees to deliver the same and receive the amount. The contract may also be cash-settled so that no physical delivery is made. Like other futures contracts, when two parties agree for a trade, the clearing corporation steps in and assumes a counter-party position to each of them. Each of the parties has to pay initial upfront margin to the clearing corporation (through their brokers/trading members). Then, as time passes, their positions are marked-to-the-market depending upon the market price of the futures contract traded between the parties. If the market price increases, the account of the long is credited and that of the short is debited, while if the price of futures decreases, the short is credited and the long is debited. Accordingly, additional margin is called for from the party whose account is debited, on a day-to-day basis. This is continued until the date of maturity arrives when either the delivery is executed against payment or the difference between the spot value and the contracted price is settled in cash and their accounts are accordingly credited or debited.

Sample Futures Contract

The specifications for futures contracts trading on the National Stock Exchange of India, NSE, are given in Box 3.7. As of now, such contracts are allowed to be traded on a total of 31 securities as shown in Box 3.8. It may be noted that the contract size, in terms of the number of shares involved, is not uniform for all the stocks. This is because it is stipulated by SEBI that the value of a contract, when initiated, should not be less than Rs 2 lakhs. Accordingly, the contract size is determined in keeping with the prices of the shares. It can be easily visualised that these sizes are subject to revision in case significant share price changes occur. Further, it has been laid by SEBI that single stock futures contracts shall be permitted upto a maximum maturity of 12 months. It was also stated that, initially, such contracts shall have maturity of three months. Therefore, at any point in time atleast three single stock futures contracts would be available for trading. As of now, however, exactly three contracts on a particular underlying are available.

SEBI has also laid down guidelines for modification of contract specifications arising out of corporate actions. The corporate actions mean and include dividend, bonus, rights shares, issue of shares as a result of stock split, stock consolidations, schemes of mergers/de-mergers, spin-offs, amalgamations, capital restructuring and such other privileges or events of a similar nature announced by the issuer of the underlying securities. Detailed guidelines about the margin system and position limits of the traders in respect of such contracts have also been provided.

Box 3.7 *Contract Specifications for Futures on Individual Stocks*

Item	*Specification*
Security Description	As per Note 1, Box 3.8
Underlying Unit	Individual scrips as per SEBI list (given in Note 1, Box 3.8)
Contract Size	As per Note 1, Box 3.8. See also Note 2.
Price Steps	Re 0.05
Trading Hours	9.55 a.m. to 3.30 p.m.
Trading Cycle	A maximum of three month trading cycle—the near month (one), the next month (two) and the far month (three). New contract is introduced on the next trading day following the expiry of near-month contract.
Last Trading/Expiration Day	The last Thursday of the expiry month, or the preceding trading day if the last Thursday is a trading holiday.
Settlement	In cash on T+1 basis.
Final Settlement Price	Closing price of the underlying security in the capital market segment of the National Stock Exchange on the expiration day of the futures contract.
Daily Settlement Price	Closing price of futures contract. Computed on the basis of the last half-an-hour weighted average price of such contract in the F&O segment. In case of non-trading during the last half-hour, the daily settlement price to be computed as $F = Se^{rt}$, where r is the rate of interest (MIBOR).
Settlement Day	Last trading day.
Margins	Upfront initial margin on daily basis.

Source: NSE

Note 1 At present, SEBI allows trading of futures contracts in a tota of 31 individual securities. These are given in Box 3.8. Also given ir the table are the symbols of the securities and the contract size foi each of these.

Note 2 The value of a futures contract on an individual stock cannoi be less than Rs 2 lac at the time of its introduction. The permitted loi size for the futures contracts on individual securities must be ir multiples of 100 and fractions, if any, are rounded off to the next higher multiple of 100.

Box 3.8 ***List of Securities on which Futures Contracts are Available***

S. No.	*Name*	*Symbol*	*Lot Size*
1.	Associated Cement Co. Ltd.	ACC	1500
2.	Bajaj Auto Ltd.	BAJAJAUTO	800
3.	Bharat Petroleum Corporation Ltd.	BPCL	1200
4.	Bharat Heavy Electricals Ltd.	BHEL	1100
5.	BSES Ltd.	BSES	1100
6.	CIPLA Ltd.	CIPLA	200
7.	Digital Equipment (I) Ltd.	DIGITALEQUIP	400
8.	Dr. Reddy's Laboratories	DRREDDY	200
9.	Grasim Industries Ltd.	GRASIM	700
10.	Gujarat Ambuja Cement Ltd.	GUJAMBCEM	1100
11.	Hindustan Lever Ltd.	HINDLEVER	300
12.	Hindustan Petroleum Corporation Ltd.	HINDPETRO	1000
13.	Hindalco Industries Ltd.	HINDALCO	1300
14.	HDFC Ltd.	HDFC	300
15.	ICICI Ltd.	ICICI	2800

S. No.	Name	Symbol	Lot Size
17.	ITC Ltd.	ITC	300
18.	Larsen & Toubro Ltd.	L&T	1000
19.	Mahindra & Mahindra Ltd.	M&M	1600
20.	Mahanagar Telephone Nigam Ltd.	MTNL	2500
21.	Ranbaxy Labs Ltd.	RANBAXY	500
22.	Reliance Petroleum Ltd.	RELPETRO	600
23.	Reliance Industries Ltd.	RELIANCE	4300
24.	Satyam Computer Services Ltd.	SATYAMCOMP	1200
25.	State Bank of India	SBIN	1000
26.	Sterlite Optical Technology Ltd.	STROPTICAL	600
27.	TELCO Ltd.	TELCO	3300
28.	Tata Power Co. Ltd.	TATAPOWER	1800
29.	Tata Iron and Steel Co. Ltd.	TISCO	1600
30.	Tata Tea Ltd.	TATATEA	1100
31.	Videsh Sanchar Nigam Ltd.	VSNL	700

Pricing of Futures Contracts on Stocks

In the normal markets, the futures contracts are priced according to the cost of carry model. In terms of this, the pricing of futures mimics a process by which a risk-averse seller of the contracts buys the security at current price, holds it till the date of maturity of the contract, incurring an interest cost in the process. The dividends, if any, resulting from holding the security, during the currency of the contract, represent negative cost (called carry returns) are netted from the interest cost and the net cost is effectively the cost of maintaining a risk-free position. Accordingly, the valuation of futures is done as follows:

When no dividend is expected from the underlying stock,

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

where F is the value of futures contract, S_0 is the spot value of stock, r is the continuously compounded risk-free rate of return, and t is the time to maturity (in years).

When dividend is expected from the underlying stock,

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

where I is the discounted value of the dividend receivable from the stock, and other symbols are same as defined above.

Example 3.8

A share is currently selling at Rs 208.80. Calculate the price of October futures contract on this share assuming the risk-free rate of return to 8 percent and the time to maturity as 56 days. Take the market lot to be 100.

Here S_0 = 208.80, continuously compounded rate of return = ln(1.08) = 0.077, time to maturity = 56/365 = 0.1534.

Accordingly,

$$F = S_0 e^{rt}$$
$$= 208.80e^{(0.077)(0.1534)}$$
$$= 208.80 \times 1.012 = 211.281$$

With the market lot equal to 100, the value of the futures contract works out to be 100 × 211.281 = Rs 211,281.

Example 3.9

Re-work the value of futures contract in Example 3.8 assuming that a dividend of Rs 2.60 per share is expected in 20 days from now.

Present value of the dividend, $I = De^{-rt}$

$$= 2.60e^{-(0.077)(20/365)}$$
$$= 2.59$$
$$F = (S_0 - I)e^{rt}$$
$$= (208.80 - 2.59)e^{(0.077)(56/365)}$$
$$= 208.661$$

With this, the value of a futures contract = 100 × 208.661 = Rs 208,661.

It is easy to visualise that carrying cost is typically positive, with the result that futures are normally priced higher than the spot price.

EXERCISES

1. What are the major stock indices in India? Discuss in detail about the Sensex and S&P CNX Nifty indices.
2. How are futures contracts on stock indices valued using the cost of carry model when (i) no dividends are expected, and (ii) dividends are expected on securities included in the index?
3. Explain how speculators and arbitrageurs can profitably use stock index futures.
4. What do you understand by beta of a security? Explain the method of its calculation.
5. Differentiate between systematic and unsystematic risk. Do you agree that hedging with stock index futures controls both these types of risk?
6. Explain how the stock index futures are used for adjusting the beta value of a portfolio (i) upward, and (ii) downward.
7. Write a detailed note on hedging (i) a long position in stocks, and (ii) a short position in stocks, using stock index futures.
8. What are single stock futures? How are they priced?
9. How are futures on individual stocks different from futures on stock indices in terms of their use for hedging purposes?
10. Using the following data, obtain the value of a futures contract to an index:

    Spot value of the index = 1216
    Risk-free rate of return = 7% p.a.
    Time to expiration = 146 days
    Contract multiplier = 200
11. A stock index is currently at 820. The continuously compounded risk-free rate of return is 9% per annum and the dividend yield on the index is 3 per cent per annum. What should the futures price for a contract with 3 months to expiration be?
12. Assume that a market-capitalisation weighted index consists of five stocks only. Currently, the index stands at 970. Obtain the price of a futures contract, with expiration in 115 days, on this index having reference to the following additional information:
    (a) Dividend of Rs 6 per share expected on share B, 20 days from now.

(b) Dividend of Rs.3 per share expected on share E, 28 days from now.

(c) Continuously compounded risk-free rate of return = 8% p.a.

(d) Lot size: 300

(e) Other information:

Company	*Share Price (Rs)*	*Market Capitalization (crores of Rs)*
A	22	110
B	85	170
C	124	372
D	54	216
E	25	200

13. On April 5, 2002, BSXMAY2002 (the futures contracts on the BSE SENSEX expiring on 30.05.2002) were selling at 3540.10 while the spot index value was 3500.57. Using these values, obtain the annualised risk-free rate of return implied in the futures.

14. For a certain security with beta = 1.3, the variance of daily returns is found to be 12.4. The standard deviation of daily returns on an index is found to be 1.8. Obtain a measure of the risk faced by holder of this security who decides to hedge with the index in question.

15. From the following information, obtain the portfolio beta:

Security	*No. of Shares*	*Price per share (Rs)*	*Beta*
1	2500	38	1.32
2	1800	107	0.65
3	6400	62	0.92
4	5700	22	1.56

16. The current spot price of a 100-rupee share is Rs 302.60. Obtain the fair price of December futures contract on this share assuming the risk-free rate of return to be 9 per cent and the market lot size as 250. The maturity date is 73-days from today. How would the value of the contract be affected if a dividend of 8 per cent is expected in 30 days' time?

17. Consider the portfolio of Mr Anand given here:

	Number of shares	*Share price as on April 18, 2002*
CIPLA	4000	1029.75
Hind Lever	5200	208.40
ICICI Ltd.	6600	61.20
Infosys Tech.	2400	3958.95
NIIT Ltd.	5600	308.80
Tata Engg.	1500	128.05
Zee Telefilm	4000	168.00

(i) Calculate the beta of his portfolio, using information given in Box 3.6.

(ii) The May futures on BSE Sensex are quoted at 3444.60. Assuming the market lot to be 100, calculate the number of contracts Mr Anand should short for hedging his portfolio against possibly falling markets.

Subject: Financial Derivatives (4539292)

MBA SEM 03
Module 03

FUNDAMENTALS OF OPTIONS

❖ Introduction

In the preceding chapters, we discussed about the nature and characteristics of forward and futures contracts. We now consider options contracts. The present chapter deals with the characteristics of options contracts, the risk and return features of options, and various trading strategies involving options. The next chapter focuses on the question of valuation of options.

Options, like futures, are also speculative financial instruments. An option is a legal contract which gives the holder the right to buy or sell a specified amount of underlying asset at a fixed price within a specified period of time. It gives the holder the *right* to buy (or sell) a designated asset. The holder is, however, *not obliged* to sell (or buy) the same. This is in contrast to forward and futures contracts where both the parties have a binding commitment.

There are two parties in an options contract—one party takes a *long* position, that is, it buys the option, while the other one takes a *short* position, that is, it sells the option. The one who takes a short position is the one who *writes* the option, and is called the *writer* of the option.

It is significant to note that although options are standardized, no physical certificate is created when options are written. All transactions are simply book-keeping entries.

CHARACTERISTICS OF OPTIONS CONTRACTS

Call Options and Put Options

Options may be categorized as *call* options and put options. A call option is a contract which gives the owner the *right to buy* an asset for a certain price on or before a specified date. For example, if you buy a call option on a certain share *XYZ*, you have the right to purchase 100 shares (assuming of course, that the option involves 100 shares) of *XYZ* at a specified price any time between today and a specified date. The fact that the owner of the option has no obligation to exercise it implies that he has a limited liability. Should the price of the asset fall below the specified price such that it is not profitable for him to buy it, he may decide not to acquire the underlying asset.

On the other hand, a put option gives its owner the *right to sell* something for a certain predetermined price on or before a specified date. Thus, if you buy a put option on shares of *XYZ*, you have the right to sell 100 shares of this company at the specified price at any time between today and the specified date. Of course, you may not like to exercise your option if the price of this share increases beyond the specified price.

The positions of the buyer and seller in call and put options are given below.

Option Type	*Buyer of Option (Long Position)*	*Writer of Option (Short Position)*
Call	Right to buy asset	Obligation to sell asset
Put	Right to sell asset	Obligation to buy asset

American vs European Options

The definitions of options, both call and put, given above apply to the *American*-style options. An American option can be exercised by its owner at *any time on* or *before* the expiration date. Besides the American type, there are *European*-style options as well. In the case of European options, the owner can exercise his right only *on* the expiration date, and not before it. It may be pointed out, however, that most of the options traded in the world, including those in Europe, are American-style options.

Physical Delivery vs Cash-Settled Options

When an option is exercised on or before the date of expiry, it may be settled by transferring the specified underlying asset by short to long in case of call and by long to short in case of a put option, at the agreed price. Thus, in a call option contract involving stock, a specified number of shares are transferred by the short to the long. This is settlement of the contract through physical delivery.

An options contract may also be designed so as to be settled by cash payment. In such cash settlement contracts, the traders make/ receive payments to settle any losses or gains on exercise/maturity of the contract instead of making physical delivery.

Assets Underlying Options

The asset that can be bought or sold with an option is known as the *underlying asset*, or simply, the *underlying*. There is a wide variety of assets on which options are traded the world over. The assets range from agricultural commodities including wheat, live cattle and live hogs to foreign currencies, and from interest rates to individual stocks and stock indices. For instance, the Chicago Mercantile Exchange in USA deals with options on items listed below:

(i) Agricultural commodities including feeder cattle, live cattle, live hogs, broiler chickens, and random length lumber,

(ii) Foreign currencies including the British pound, Canadian dollar, French franc, Japanese yen, Swiss franc, Deutsche mark, Australian dollar, Currency Forward etc.,

(iii) Interest rates including Eurodollar, Euromark, 90-day Treasury bill, one-year Treasury bill etc,

(iv) Stock indices covering S&P 500 Index, S&P Midcap 400 Index, Nekkei 225 Index, Major Market Index, Russel 2000 Index and FT-SE 100 Share Index.

For each type of options contract, contract sizes are provided. For example, in options on stocks, one contract generally gives the holder the right to buy or sell 100 shares. In case of options on foreign currency, similarly, the size of the contract varies with the currency underlying it.

A Sample Commodity Options Contract

A sample options contract on wheat traded at Chicago Board of Trade (CBOT) is presented in Box 4.1. Evidently, one contract involves 5,000 bushels of a specified variety of wheat or alternatives as provided by the exchange. The price of one contract moves in units of $ 12.50.

Box 4.1 *Specifications for Options Contract on Wheat*

Trading Unit	5000 bushels
Symbol	W
Deliverable Grade	No. 2 Soft Red, No. 2 Hard Red Winter, No. 2 Dark Northern Spring at par, and other permissible substitution
Price Quotation	Cents and quarter cents per bushel
Tick Size	1/4 cent per bushel, $ 12.50 per contract
Contract Months	Mar, May, Jul, Dec
Last Trading Day	Seven business days before the last business day of the contract month

Source: CBOT

Index Options Index options are also very popular. In case of options on indices, a contract usually provides for a certain multiple of the index. For instance, contract specifications for TOPIX (Tokyo Stock Price Index) stipulate the contract unit to be Yen 10,000 *times* TOPIX. Similarly, the S&P 100 and S&P 500 are the indices most popularly traded indices in the USA. One contract in such cases provides to buy or sell 100 times the index at the specified strike price. To illustrate, we may consider one contract on the S&P 100 with a strike price of 262. In case it is exercised when the index is at 280, the writer of the option would pay the holder a sum of $(280 - 262) \times 100 = \$1800$. The index value used is the value as at the end of the day, when the exercising instructions are given. Index options are also traded in India. They are available on the Sensex of The Stock Exchange, Mumbai, and S&P CNX Nifty of the NSE.

Options on Futures Many exchanges provide for trading of options on futures as well. In such an option, the underlying asset is a futures contract. The futures contract normally matures after the expiration of the option. When the holder of a call option decides to exercise it, he/she acquires from the writer (i.e. the seller) of the option a long position in the underlying futures contract *plus* a cash amount equal to the excess of the futures price over the exercise price. Similarly, when the holder of a put option exercises, he/she acquires a short position in the underlying futures contract and a cash amount equal to the excess of exercise price over the futures price. In each case, the futures contract has a zero value and can be closed out immediately. Evidently, then, the pay-off from a futures option is the same as the pay-off from a stock option with the stock price being replaced by the futures price. In USA, such contracts are extensively traded on assets like treasury bonds, soybeans, crude oil, live cattle, gold, Eurodollars etc.

Stock Options Although a variety of options are traded the world over, our focus in the following discussion will be primarily on options on stocks (shares of companies). That is to say, we shall be concerned here basically with the call and put options on shares of companies, traded in the exchanges. Besides, options on stock indices and options on futures are discussed in Chapter 6.

Sample Contract of Options on Individual Stocks

Specifications of a sample contract on individual stocks, as traded in the Indian markets, is given in Box 4.2. Options on individual stocks are traded at the National Stock Exchange (NSE) and The Stock Exchange, Mumbai (BSE). A glance at the contract specifications reveals the following:

(a) As of now, option contracts are permitted on a total of 31 stocks.

(b) The options are American style so that they can be exercised at any time before the expiry of the contract.

(c) The contracts on different stocks involve different number of shares. They depend on the prices of the underlying securities. At initiation, a contract has to be worth at least Rs 2 lac in rupee terms.

(d) For determining the gain/loss on a contract at the end of a day, the closing price of the underlying security in the cash market segment of the exchange is considered.

(e) Settlement is done on a T + 1 basis. This means once an option is exercised (or deemed so), the settlement of the contract is done by the following trading day. The settlement does not involve transfer of shares. It is done on a cash basis.

The other characteristics of the contracts are detailed at appropriate places.

❖ Moneyness in options (ITM, ATM, OTM)

Box 4.2 ***Contract Specifications for Options on Individual Stocks***

Item	*Specification*
Underlying Unit	Individual scrips as instructed by SEBI (given in Box 4.3)
Ticker Symbol	As specified in Box 4.3
Contract Multiplier	As specified in Box 4.3
Strike Prices	Shall have a minimum of five strikes (2 in-the-money, one near-the-money, and 2 out-of-the-money)
Premium Quotation	Rupees per share
Last Trading Day	Last Thursday of the contract month. If it is a holiday, the immediately preceding business day
Expiration Day	Last Thursday of the contract month. If it is a holiday, the immediately preceding business day *Note:* Business day is a day during which the underlying stock market is open for trading.
Contract Month	1, 2, and 3 months, e.g. in the month of July:- July, August and September contracts would be available for trading. New contract is introduced on the next trading day following the expiry of near-month contract.
Exercise Style	American
Settlement Style	Cash (In cash on T + 1 basis)
Trading Hours	9.30 a.m. to 3.30 p.m.
Tick Size	0.01
	Closing price of the underlying security in the cash segment of The Stock Exchange, Mumbai. The following algorithm is used for calculating the closing value of these stocks in the cash segment.

	• Weighted average price of all the trades in the last fifteen minutes of the continuous trading session. • If there are no trades during the last fifteen minutes, then the last traded price in the continuous trading session would be taken as the official closing price.
Exercise Notice Time	It would be a specified time (Exercise Session) every day.
	All in-the-money options by certain specified ticks would deemed to be exercised on the day of expiry unless the participant communicates otherwise in the manner specified by the Derivatives Segment.
Settlement Day	Last trading day
Margins	Upfront initial margin on daily basis

Source: The Stock Exchange, Mumbai

Box 4.3 ***List of Securities on which Options Contracts are Available***

S. No.	*Name*	*Symbol*	*Lot Size*
1.	Associated Cement Co. Ltd.	ACC	1500
2.	Bajaj Auto Ltd.	BAJ	800
3.	Bharat Petroleum Corporation Ltd.	BPC	1100
4.	Bharat Heavy Electricals Ltd.	BHE	1200
5.	BSES Ltd.	BSE	1100
6.	CIPLA Ltd.	CIP	200
7.	Digital Equipment (I) Ltd.	DIG	400
8.	Dr. Reddy's Laboratories	DRR	400
9.	Grasim Industries Ltd.	GRS	700
10.	Gujarat Ambuja Cement Ltd.	GAC	100
11.	Hindustan Lever Ltd.	HLL	1000

12.	Hindustan Petroleum Corporation Ltd.	HPC	1300
13.	Hindalco Industries Ltd.	HND	300
14.	HDFC Ltd.	HDF	300
15.	ICICI Ltd.	ICI	2800
16.	Infosys Technologies Ltd.	INF	100
17.	ITC Ltd.	ITC	300
18.	Larsen & Toubro Ltd.	LNT	1000
19.	Mahindra & Mahindra Ltd.	MNM	2500
20.	Mahanagar Telephone Nigam Ltd.	MTN	1600
21.	Ranbaxy Labs Ltd.	RBX	500
22.	Reliance Petroleum Ltd.	RPL	4300
23.	Reliance Industries Ltd.	RIL	600
24.	Satyam Computer Services Ltd.	SAT	1200
25.	State Bank of India	SBI	1000
26.	Sterlite Optical Technology Ltd.	SOT	600
27.	TELCO Ltd.	TEL	3300
28.	Tata Power Co. Ltd.	TPW	1600
29.	Tata Iron and Steel Co. Ltd.	TIS	1800
30.	Tata Tea Ltd.	TAT	1100
31.	Videsh Sanchar Nigam Ltd.	VSN	700

Expiration Date

Standardized options have specified dates mentioned for maturity. The date mentioned in an options contract is called *expiration date* or the *maturity date*. After the maturity date, an option has no worth. Different types of options have different expiration dates.

Generally, the maximum life of an option on stocks is nine months. The expiration date for contracts on TOPIX options on the Tokyo Stock Exchange in Japan is the business day prior to the second Friday, except that the expiration date for March, June, September and December contracts is the second Friday. For the exchanges in the U.S.A. on the other hand, the expiration date falls on the Saturday following the third Friday of the month of expiry. Generally, three life cycles are used there for options, so that each stock option falls into one of the three cycles that determines its expiration months. The three cycles and the months included in various cycles are indicated below:

- *January cycle*—January, April, July, and October
- *February cycle*—February, May, August, and November
- *March cycle*—March, June, September, and December

For each cycle, the expiration months are as given in Table 4.1. With reference to the above information and the information in the table, we see that there are always options that expire in four months available; of which two months are the upcoming ones and two others are distant ones. For example, in the January cycle given in the table, it may be observed that from March 24, 2003, (i.e. the Monday following the third Friday) to April 18, 2003 (which is the third Friday of the month), options expiring in April, May, July and October would be traded. Note that while options expiring in March would already have been expired on the third Friday of March, 2003 and hence would not be available in the current period, the options with expiry in April (i.e. current month) and May (next month) would be available and so will be the options with expiry in July and October (see list above showing months included in various-cycles). In Table 4.1, options expiring in May have been shown italicized to indicate that they would be the newly introduced options in this period. In the same way, from April 21, 2003, the Monday following the third Friday, to May 16, 2003, the options in this cycle with expiry in the months of May, June, July and October would be traded. The options with expiry in April would have expired during the period under consideration and the ones with June would have been introduced.

In India at present, a total of three series of contracts are available for trading on a given day—the near month contracts, next-month contracts and distant-month contracts. To illustrate, in the month of September of a given year, the contracts expiring in September, October and November can be traded before last Thursday of the month when the September contracts would expire. From the following day, the December contracts would be introduced so that the October contracts become near-month contracts and the

November and December contracts being the next month and the distant-month contracts.

Table 4.1

Option Cycles

From Monday after 3rd Friday of	*Upto 3rd Friday of*	*Months Available*			
1. January cycle:					
January	February	Feb	*Mar*	Apr	Jul
February	March	Mar	Apr	Jul	*Oct*
March	April	Apr	*May*	Jul	Oct
April	May	May	Jun	Jul	Oct
May	June	Jun	Jul	Oct	*Jan*
June	July	Jul	*Aug*	Oct	Jan
July	August	Aug	*Sep*	Oct	Jan
August	September	Sep	Oct	Jan	*Apr*
September	October	Oct	*Nov*	Jan	Apr
October	November	Nov	*Dec*	Jan	Apr
November	December	Dec	Jan	Apr	*Jul*
December	January	Jan	*Feb*	Apr	Jul
2. February cycle:					
January	February	Feb	*Mar*	May	Aug
February	March	Mar	*Apr*	May	Aug
March	April	Apr	May	Aug	*Nov*
April	May	May	*Jun*	Aug	Nov
May	June	Jun	*Jul*	Aug	Nov
June	July	Jul	Aug	Nov	*Feb*
July	August	Aug	*Sep*	Nov	Feb
August	September	Sep	*Oct*	Nov	Feb
September	October	Oct	Nov	Feb	*May*
October	November	Nov	*Dec*	Feb	May
November	December	Dec	*Jan*	Feb	May
December	January	Jan	Feb	May	*Aug*
3. March cycle:					
January	February	Feb	Mar	Jun	*Sep*
February	March	Mar	*Apr*	Jun	Sep
March	April	Apr	*May*	Jun	Sep
April	May	May	Jun	Sep	*Dec*
May	June	Jun	*July*	Sep	Dec
June	July	July	*Aug*	Sep	Dec
July	August	Aug	Sep	Dec	*Mar*
August	September	Sep	*Oct*	Dec	Mar
September	October	Oct	*Nov*	Dec	Mar
October	November	Nov	Dec	Mar	*Jun*
November	December	Dec	*Jan*	Mar	Jun
December	January	Jan	*Feb*	Mar	Jun

Exercise Price

It is the price at which the parties with the long and short positions buy and sell the underlying asset. For example, in a December call on shares of a company with a strike price of Rs 90, the implication is that the party with the long position shall, at its option, buy 100 shares (if the call involves 100 shares) of the company at a rate of Rs 90 per share. The "strike price" of Rs 90 is also called the exercise price.

In the case of options on stocks, the exercise prices on which options on a particular share are to be traded are selected by the exchange. Typically, exercise (strike) prices just above and below the current market price of the underlying share are opened for trading. If the price of the share becomes higher than the highest strike price, the exchange would introduce a new series of options prices for all expiration months with a strike price just above the old highest strike price. Similarly, if the price of the share becomes lower than lowest strike price, a new series of options prices for various expiration months with a strike price just below the old lowest strike price would be issued by the exchange.

It may be noted that the standardized-options have uniform exercise prices in certain increments. In the American options markets for instance, the options traded have uniform striking prices in the increments of $ 2.50 or $ 5, depending upon the price of the underlying stock. Generally, strike price intervals of $ 2.50 are used for stocks priced below $ 25 or for stocks with relatively low volatility. In case of stocks which quote at high prices, may be $ 200 or more, the strike price intervals of $ 10 are also used.

For trading in the Indian markets, an exchange provides for a minimum of five strike prices for every option type, namely call and put, during the trading month. Two of the contracts with strike prices above, two of them having strike prices below and one contract with exercise price equal to the current price of the security. The strike price intervals for options are as given here:

Price of Underlying	*Strike-price Interval*
≤ Rs 100	5
> Rs 100 and ≤ Rs 200	10
> Rs 200 and ≤ Rs 500	20
> Rs 500 and ≤ Rs 1000	30
> Rs 1000 and ≤ Rs 2500	50
> Rs 2500	100

New contracts with new strike prices for existing expiration dates are introduced for trading on a day, based on the previous day's underlying closing values, as and when required. For deciding on the strike price for options equal to the current price, the closing value of the underlying security is rounded off to the nearest multiplier of the strike price interval.

Option Premium

A glance at the rights and obligations of the buyers and sellers reveals that options contracts are skewed. One may naturally wonder as to why the seller (the writer) of an option should be always obliged to sell/buy an asset whenever the other party desires. The answer is that the writer of an option receives a consideration for the obligation he/she undertakes on himself/herself. This is known as the *price* or the *premium* of the option. Option contracts are created when a buyer and a seller agree on a price. The buyer pays the premium to the seller which belongs to the seller whether the option is exercised or not. If the owner of an option decides *not* to exercise the option, the option expires worthless, the amount of premium becomes the profit of the option writer, while if the option is exercised, the premium gets adjusted against the loss the writer incurs upon such exercise.

Comparison of Market Price of the Asset and the Exercise Price: In-the-Money, At-the-Money and Out-of-the-Money Options

At any time, an option may be *in-the-money*, *at-the-money* or *out-of-the-money*. A call option is said to be *in-the-money* if the price of the stock (which we shall assume is the underlying asset) is greater than the exercise price, while if the stock price is smaller than the exercise price, the call is said to be *out-of-the-money*. For the put options, the reverse holds, so that if the exercise price of a put is greater than the stock price, then the put is said to be *in-the-money* and *out-of-the-money* if the former is a lower than the latter. In each case, however, the option is said to be *at-the-money* if the stock price matches with the exercise price. These concepts are tabulated below, wherein S_0 indicates the present value of the stock (i.e. the value at a given point of time) and E is the exercise price:

Condition	*Call Option*	*Put Option*
$S_0 > E$	In-the-Money	Out-of-the-Money
$S_0 < E$	Out-of-the-Money	In-the-Money
$S_0 = E$	At-the-Money	At-the-Money

Intrinsic Value and Time Value

The premium or the price of an option is made up of two components, namely, the *intrinsic value* and the *time value*. The intrinsic value is also termed as the *parity value* and the time value as the *premium over parity*.

For an option, the *intrinsic value* refers to the amount by which it is in money if it is in-the-money. Therefore, an option which is out-of-the-money or at-the-money has a zero intrinsic value.

For a call option which is in-the-money, then, the intrinsic value is the excess of stock price (S_0) over the exercise price (E), while it is zero if the option is other than in-the-money. Symbolically,

Intrinsic Value of a Call Option = Max $(0, S_0 - E)$.

In case of an in-the-money put option, however, the intrinsic value is the amount by which the Exercise Price (E) exceeds the Stock Price S_0, and zero otherwise. Thus,

Intrinsic Value of a Put Option = Max $(0, E - S_0)$.

The *time value* of an option is the difference between the premium of the option and the intrinsic value of the option. For a call or a put option, which is at-the-money of out-of-the-money, the entire premium amount is the time value. For an in-the-money option, time value may or may not exist. In case of a call which is in-the-money, the time value exists if the call price, C, is greater than the intrinsic value, $S_0 - E$. Generally, other things being equal, the longer the time of a call to maturity, the greater shall the time value be.

This is also true for the put options. An in-the-money put option has a time value if its premium exceeds the intrinsic value, $E - S_0$. Like for call options, put options which are at-the-money or out-of-the-money have their entire premia as the time value. Accordingly,

Time Value of a Call = $C - \{\text{Max}\ (0, S_0 - E)\}$, and

Time Value of a Put = $P - \{\text{Max}\ (0, E - S_0)\}$

Example 4.1

Consider the following data about calls on a hypothetical stock:

Option	*Exercise Price*	*Stock Price*	*Call Option Price*	*Classification*
1	Rs 80	Rs 83.50	Rs 6.75	In-the-money
2	Rs 85	Rs 83.50	Rs 2.50	Out-of-money

The first call is in-the-money while the second one is out-of-the-money, as may be observed from the stock prices and the respective exercise prices. Now, we may show how the market prices of the two calls can be divided between intrinsic and time values.

Option	S_0	E	C	Intrinsic Value $\max(0, S_0 - E)$	Time Value $C - \max(0, S_0 - E)$
1	83.50	80	6.75	3.50	6.75 − 3 = 3.75
2	83.50	85	2.50	0	2.50 − 0 = 2.50

Options and the OCC

The provisions specified in the options contracts are guaranteed by the Options Clearing Corporations (OCC). The buyers and sellers of options do not deal with each other directly. Instead, the clearing corporations act as an intermediary between them, by issuing standardized options and by ensuring that the the options contracts are honoured. It should, however, be understood that an option clearing corporation by itself does not buy and sell options. The OCC comes into picture only after two parties trade a contract. It takes an opposite position to each of the traders—a short position in respect of the party with the long position and a long position against the party with a short position. Thus, the buyer of an option relies on the OCC for fulfilment of contractual obligations. Similarly, the option writer has an obligation to the OCC.

Open Interest

Every time a trader takes a long or short position in an options contract, it either adds to his existing interest in the option or reduces it. To illustrate, if an investor already holds a net long position in an options contract, a new long position will add and a new short position will reduce his exposure in the contract. However, at any given point in time, the total outstanding long positions in respect of an options contract are exactly equal to the total outstanding positions in it. The number of outstanding positions at a given time is known as open interest. The open interest in an options contract is an index of its liquidity. The financial press regularly publishes information on the open interest in addition to the usual price data. A sample of such data as published in India is given in Box 4.4.

Options to Option Holders

Once a call or a put option is bought and sold, the holder of it may take one of three courses of action, on a given day. They are:

1. Do nothing.
2. Close out the position in the options market. This may be done by reversing the transaction so that, for example, one who is long, the call option (i.e. one who owns a call) may write a matching call option, or the one who has written a call earlier may buy one. Also, the owner of a call or put may sell it at the current market price.
3. Exercise the option if it is an "American" one. In case of a call option, the call writer would have to deliver the underlying asset and the holder of the call would pay an amount equal to the exercise price. Similarly, if the owner of an American put decides to exercise the option, the seller shall be obliged to buy the underlying asset and pay the owner an amount equal to the exercise price.

Box 4.4 ***Published Information on Option Prices***

Contracts, (Str.Pr.) Premium [Traded Qty., Notion Value in Rs. Lks, No. of Contracts]	Open Int.	Exp.Date
EQUITY OPTIONS ON BSE		
Call Options		
BHEL (180) 161.60 [–, –, –]	1200	25/04/2002
ITC (630) 15:38 [–, –, –]	300	30/05/2002
Reliance Inds. (300) 287.05 [–, –, –]	1800	25/04/2002
Satyam (280) 259.55 [–, –, –]	1200	25/04/2002
Satyam (260) 259.55 [–, –, –]	1200	25/04/2002
Sterlite Opt. (140) 133.25 [–, –, –]	4200	25/04/2002
Put Options		
Digital Global (510) 680.75 [–, –, –]	800	25/04/2002
Sterlite Opt. (130) 133.25 [–, –, –]	600	25/04/2002

EQUITY OPTIONS ON NSE

Call Options

ACC (140.00) 12.00, 12.00, 12.00 [1500, 2.28, 1] ... 18000 ... 25/04/2002
ACC (150.00) 3.50, 3.50, 1.00 [150000, 228.96, 100] ... 277500 ... 25/04/2002
ACC (160.00) 0.10, 0.10, 0.05 [97500, 156.06, 65] ... 517500 ... 25/04/2002
ACC (170.00) 0.05, 0.05, 0.05 [6000, 10.20, 4] ... 240000 ... 25/04/2002
ACC (150.00) 6.40, 7.25, 6.10 [63000, 98.77, 42] ... 184500 ... 30/05/2002
ACC (160.00) 3.00, 3.30, 2.75 [33000, 53.78, 22] ... 124500 ... 30/05/2002
ACC (170.00) 1.30, 1.30, 1.05 [22500, 38.52, 15] ... 45000 ... 30/05/2002
Bajaj Auto (480.00) 3.00, 3.00, 3.00 [800, 3.86, 1] ... 1600 ... 25/04/2002
Bajaj Auto (480.00) 15.00, 15.00, 15.00 [800, 3.96, 1] ... 800 ... 30/05/2002
BHEL (160.00) 2.00, 2.00, 200 [1200, 1.94, 1] ... 8400 ... 25/04/2002
BHEL (170.00) 0.50, 0.50, 0.05 [20400, 34.71, 17] ... 88800 ... 25/04/2002
BHEL (190.00) 0.05, 0.05,0.05 [1200, 2.28, 1] ... 216000 ... 25/04/2002
BHEL (200.00) 0.05, 0.10, 0.05 [7200, 14.41, 6] ... 157200 ... 25/04/2002
BHEL (160.00) 12.90, 12.90, 800 [15600, 26.44, 13] ... 14400 ... 30/05/2002
BHEL (170.00) 7.30, 7.30, 3.70 [129600, 22.693, 108] ... 17400 ... 30/05/2002
BHEL (180.00) 4.00, 4.00, 2.00 [52800, 96.52, 44] ... 111600 ... 30/05/2002
BHEL (190.00) 1.50, 1.50, 1.50 [1200, 2.30, 1] ... 3600 ... 30/05/2002
BHEL (200.00) 1.00, 1.00, 1.00 [3600, 7.24, 3] ... 3600 ... 30/05/2002
BPCL (280.00) 4.05, 4.05, 1.00 [20900. 59.14, 19] ... 42900 ... 25/04/2002
BPCL (300.00) 0.05, 0.05, 0.05 [2200, 6.60, 2] ... 141900 ... 25/04/2002
BPCL (320.00) 0.05, 0.05, 0.05 [5500, 17.60, 5] ... 214500 ... 25/04/2002
BPCL (340.00) 0.05, 0.05, 0.05 [13200, 44.89, 12] ... 182600 ... 25/04/2002
BPCL (360.00) 0.05, 0.05, 0.05 [2200, 7.92, 2] ... 79200 ... 25/04/2002
BPCL (260.00) 32.00, 32.00, 32.00 [1100, 3.21, 1] ... 6600 ... 30/05/2002
BPCL (280.00) 16.25, 17.00, 11.00 [59400, 17.468, 54] ... 130900 ... 30/05/2002
BPCL (300.00) 8.45, 8.60, 8.60, 6.20 [45100, 138.67, 41] ... 154000 ... 30/05/2002
BPCL (320.00) 3.90. 3.90. 2.90 [15400, 49.79, 14] ... 94600 ... 30/05/2002
BPCL (340.00) 1.50, 1.50, 1.00 [12100, 41.29, 11] ... 66000 ... 30/05/2002
Cipla (1000.00) 0.50, 0.50, 0.50 [200, 2.00, 1] ... 800 ... 25/04/2002
Cipla (1050.00) 0.25, 0.25, 0.25 [400, 4.20, 2] ... 9400 ... 25/04/2002
Cipla (1000.00) 31.20, 31.20, 26.00 [2600, 26.76, 13] ... 3800 ... 30/05/2002
Cipla (1050.00) 13.50, 13.50, 11.15 [600, 6.37, 3] ... 1000 ... 30/05/2002
Digital Global (570.00) 112.00, 115.00, 91.00 [3200, 21.33, 8] ... 4400 ... 25/04/2002
Digital Global (600.00) 100.00, 100.00, 92.00 [1200, 8.36, 3] ... 5600 ... 25/04/2002
Digital Global (630.00) 60.10, 62.00, 55.00 [5200, 35.84, 13] ... 10800 ... 25/04/2002
Digital Global (660.00) 43.90, 45.00, 22.00 [33200, 229.04, 83] ... 47600 ... 25/04/2002
Digital Global (690.00) 12.05, 16.05, 0.25 [72000, 501.26, 180] ... 93600 ... 25/04/2002
Digital Global (720.00) 3.75, 4.75, 0.50 [17200, 124.25, 43] ... 50800 ... 25/04/2002
Digital Global (630.00) 78.00, 78.60, 69.75 [1200, 8.44, 3] ... 3200 ... 30/05/2002
Digital Global (660.00) 50.50, 50.50, 46.00 [8400, 59.42, 21] ... 13600 ... 30/05/2002
Digital Global (690.00) 31.65, 35.80, 27.10 [36000, 259.44, 90] ... 38800 ... 30/05/2002
Digital Global (720.00) 20.00, 20.00, 13.50 [25200, 185.71, 63] ... 37600 ... 30/05/2002
Digital Global (750.00) 15.00, 15.00, 8.10 [1200, 9.13, 3] ... 1200 ... 30/05/2002
Dr. Reddy's (1050.00) 6.50, 8.00, 2.00 [2400, 25.33, 6] ... 13600 ... 25/04/2002
Dr. Reddy's (1100.00) 0.10, 0.10,0.10 [400, 4.40, 1] ... 30000 ... 25/04/2002
Dr. Reddy's (1050.00) 31.00, 32.20, 31.00 [2800, 30.28, 7] ... 5600 ... 30/05/2002
Dr. Reddy's (1100.00) 15.00, 15.00, 15.00 [400, 4.46, 1] ... 3600 ... 30/05/2002
Dr. Reddy's (1150.00) 8.10, 8.10, 8.10 [400, 4.63, 1] ... 400 ... 30/05/2002
HLL (200.00) 9.50, 10.00, 9.50 [3000, 6.29, 3] ... 11000 ... 25/04/2002
HLL (220.00) 0.05, 0.05, 0.05 [4000, 8.80, 4] ... 163000 ... 25/04/2002
HLL (210.00) 0.65, 1.25, 10 [27000, 56.89, 27] ... 73000 ... 25/04/2002
HLL (230.00) 0.05, 0.05, 0.05 [2000, 4.60, 2] ... 122000 ... 25/04/2002
HLL (220.00) 3.20, 3.20, 2.00 [17000, 37.82, 17] ... 65000 ... 30/05/2002
HLL (210.00) 6.00, 6.05, 4.90 [19000, 40.93, 19] ... 56000 ... 30/05/2002
HLL (200.00) 15.00, 15.00, 12.00 [2000, 4.27, 2] ... 3000 ... 30/05/2002
HLL (960.00) 7.00, 7.00, 0.10 [16900, 44.53, 13] ... 39000 ... 25/04/2002

Put Options

ACC (150.00) 0.03, 0.35, 0.05 [42000, 63.08, 28]	286500	25/04/2002
ACC (140.00) 1.00, 1.00, 1.00 [7500, 10.58, 5]	9150	30/05/2002
ACC (150.00) 3.25, 3.25, 2.95 [37500, 57.39, 25]	57000	30/05/2002
BHEL (170.00) 2.95, 3.95, 2.00 [4800, 8.30, 4]	46800	25/04/2002
BHEL (180.00) 15.00, 15.00, 15.00 [1200, 2.34, 1]	57600	25/04/2002
BHEL (160.00) 1.30, 3.80, 3.00 [15600, 25.51, 13]	12000	30/05/2002
BHEL (170.00) 7.50, 9.90, 6.55 [38400, 68.36, 32]	46800	30/05/2002
BPCL (280.00) 1.20, 3.40, 0.75 [34100, 95.17, 31]	75900	25/04/2002
BPCL (300.00) 14.95, 14.95, 14.95 [1100, 3.46, 1]	81400	25/02/2002
BPCL (320.00) 36.00, 40.00, 36.00 [2200, 7.88, 2]	14300	25/04/2002
BPCL (260.00) 2.90, 4.00, 2.90 [13200, 34.75, 12]	45100	30/05/2002
BPCL (280.00) 9.00, 12.00, 9.00 [46200, 133.90, 2]	88000	30/05/2002
BPCL (300.00) 21.10, 25.50, 21.10 [9900, 32.03, 9]	23100	30/05/2002
BPCL (320.00) 44.00, 44.00, 44.00 [1100, 4.00, 1]	3300	30/05/2002
Cipla (1000.00) 8.00, 8.00, 8.00 [200, 2.02, 1]	400	25/04/2002
Cipla (1000.00) 25.00, 25.00, 25.00 [200, 2.05, 1]	200	30/05/2002
Digital Global (600.00) 0.10, 0.20, 0.10 [2000, 12.00, 5]	53200	25/04/2002
Digital Global (630.00) 0.15, 0.20, 0.10 [1600, 10.08, 4]	61200	25/04/2002
Digital Global (660.00) 1.00, 1.20, 0.20 19200, 60.80, 23]	57600	25/04/2002
Digital Global (690.00) 5.00, 10.00, 3.00 144400, 308.93, 111]	42400	25/04/2002
Digital Global (720.00) 20.10, 30.00, 20.10 [800, 5.96,-2]	7200	25/04/2002
Digital Global (600.00) 5.00, 8.45, 5.00 [1600, 9.71, 4]	1600	30/05/2002
Digital Global (630.00) 12.50, 14.00, 12.50 [3600, 23.16, 9]	4400	30/05/2002
Digital Global (660.00) 20.00, 26.00, 19.25 [5200, 35.51, 13]	6800	30/05/2002
Digital Global (690.00) 30.00, 43.50, 30.00 [9600, 69.83, 24]	10400	30/05/2002
HLL (210.00) 1.50, 2.50, 0.60 [12000, 25.38, 12]	46000	25/04/2002
HLL (210.00) 4.95, 4.95, 4.00 [12000, 25.76, 12]	13000	30/05/2002
HLL (200.00) 3.00, 3.00, 2.00 [9000, 18.22, 9]	12000	30/05/2002
HPCL (260.00) 0.70, 1.0,. 0.50 [28600, 74.57, 22]	67600	25/04/2002
HPCL (280.00) 18.70, 20.00, 18.70 [2600, 7.78, 2]	122200	25/04/2002
HPCL (270.00) 3.00, 5.50, 3.00 [15600, 42.78, 12]	14300	25/04/2002
HPCL (300.00) 35.00, 35.00, 35.00 [1300, 4.36, 1]	22100	25/04/2002
HPCL (240.00) 2.20, 3.25, 2.20 [39000, 94.58, 30]	71500	30/05/2002
HPCL (260.00) 6.50, 10.25, 6.50 [48100, 129.20, 37]	140400	30/05/2002
HPCL (280.00) 20.00, 23.90, 20.00 [10400, 31.34, 8]	53300	30/05/2002
HPCL (300.00) 40.00, 40.00, 40.00 [1300, 4.42, 1]	6500	30/05/2002
ICICI (60.00) 4.40, 4.40, 4.40 [2800, 1.80, 1]	92400	25/04/2002
ICICI (55.00) 1.80, 2.00, 1.80 [16800, 9.56, 6]	16800	30/05/2002
ICICI (60.00) 5.00, 5.00, [2800, 1.82,1]	2800	30/05/2002
Infosys (3700.00) 3.00, 5.00, 1.00 [1100, 40.72, 11]	25400	25/04/2002
Infosys (3800.00) 10.00, 20.00, 5.00 [11600, 442.18, 116]	25500	25/04/2002
Infosys (3900.00) 50.00, 109.00, 50.00 [4900, 194.71, 49]	6700	25/04/2002
Infosys (4000.00) 125.20, 200.00 125.20 [700, 29.24, 7]	4500	25/04/2002
Infosys (3500.00) 38.95, 38.95, 38.95 [100, 3.54, 1]	200	30/05/2002
Infosys (3600.00) 55.00, 55.00, 55.00 [100, 3.66, 1]	2900	30/05/2002
Infosys (3700.00) 72.00, 86.00, 72.00 [1400, 52.91, 14]	3800	30/05/2002
Infosys (3800.00) 110.00, 133.90, 110.00 [2800, 109.79, 28]	5300	30/05/2002
Infosys (3900.00) 152.00, 169.95, 152.00 [300, 12.18, 3]	3800	30/05/2002
Infosys (4000.00) 229.90, 235.00, 229.90 [300, 12.69, 3]	900	30/05/2002
ITC (630.00) 4.75, 14.75, 2.50 [3900, 24.81, 13]	15000	25/04/2002
ITC (690.00) 70.00, 70.00 70.00 [300, 2.28, 1]	3000	25/04/2002
ITC (630.00) 19.00, 19.90, 17.00 [1200, 7.78, 4]	1200	30/05/2002
L & T (170.00) 1.25, 3.00, 0.85 [19000, 32.65, 19]	91000	25/04/2002
L & T (180.00) 10.55, 13.00, 10.50 [5000, 9.55, 5]	90000	25/04/2002
L & T (170.00) 4.90, 6.00, 4.50 [42000, 73.56, 42]	98000	30/05/2002
L & T (180.00) 11.50, 13.45, 11.50 [14000, 26.99, 14]	14000	30/05/2002
L & T (190.00) 20.00, 22.00, 20.00 [7000, 14.75, 7]	7000	30/05/2002
L & T (160.00) 1.50, 2.15, 1.50 [14000, 22.64, 14]	48000	30/05/2002

M&M (105.00) 0.25, 0.25, 0.25 [2500, 2.63, 1]	2500	25/04/2002
M&M (105.00) 3.40, 3.40, 3.40 [2500, 2.71, 1]	7500	30/05/2002
MTNL (150.00) 5.00, 5.00, 5.00 5.00 [1600, 2.48, 1]	9600	25/04/2002
MTNL (140.00) 7.60, 8.00, 7.60 [3200, 4.73, 2]	8000	30/05/2002
MTNL (130.00) 2.45, 2.50, 2.45 [4800, 6.36, 3]	8000	30/05/2002
Ranbaxy Labs (840.00) 0.25, 0.25, 0.25 [500, 4.20, 1]	6000	25/04/2002
Ranbaxy Labs (870.00) 1.20, 1.20, 0.45 [2000, 17.42, 4]	21500	25/04/2002
Ranbaxy Labs (840.00) 6.90, 7.00, 6.05 [2500, 21.17, 5]	4500	30/05/2002
Ranbaxy Labs (870.00) 13.00, 17.00, 13.00 [1500, 13.28, 3]	3500	30/05/2002
Reliance Inds. (280.00) 0.25, 0.35, 0.05 [15000, 42.04, 25]	236400	25/04/2002
Reliance Inds. (300.00) 12.00, 12.65, 10.50 [7800, 24.29, 13]	130200	25/04/2002
Reliance Inds. (260.00) 1.25, 1.35, 1.25 [3000, 7.84, 5]	32400	30/05/2002
Reliance Inds. (280.00) 4.00, 4.45, 3.60 [33000, 93.73, 55]	82200	30/05/2002
Reliance Inds. (300.00) 13.00, 14.95, 13.00 [18600, 58.42, 31]	58800	30/05/2002
Reliance Petro. (30.00) 4.50, 4.50	12900	25/04/2002
Reliance Petro. (25.00)		

Source: *The Economic Times*, April 26, 2002

The first two choices are available to the call or put option writers also. For instance, the position of an option writer can be closed out by a reversal of the previous action by buying an option matching the one written earlier.

In the event that a call/put holder does nothing by the closure of trading on its expiration date, then the result will depend on the market price of the underlying asset on the date of expiry. For instance, for a call option, if the price of the underlying asset is lower than the exercise price, then the call would expire and become worthless. For example, if the exercise price of a call option is Rs 90 and the market price of the share involved is Rs 84 on the expiration day, then it would not be worthwhile for the holder to exercise the option. This is because, exercising the option will mean that the holder will end up paying Rs 90 for something which can be bought in the spot market for Rs 84. On the other hand, if the price of the underlying asset is more than the exercise price of a call, then it will be prudent for the call owner to exercise it and make profit from the transaction (this of course assumes that there are no transaction costs). That is on account of the fact that the owner gets for a price of, say, E, something which is more valuable than E.

Similarly, if the price of the underlying asset is more than the exercise price in respect of a put option, it becomes worthless upon expiry. Obviously, if one holds a put whereby a share can be sold to the writer for a price of Rs 47, and, suppose the share price in the market is Rs 52, then it will not make any sense to exercise the put and sell the share at the rate of Rs 47! The put option will, evidently, be advantageous to exercise if the value of the underlying asset is lower than the exercise price.

Exercise of Options

Most of the option holders do not exercise their options because they do not want to take a position in the underlying stock. Accordingly, most of the investors make a closing transaction to effectively cancel their positions. However, when an option holder does decide to exercise an option, the Option Clearing Corporation randomly assigns the exercise notice to an option writer, which is typically a brokerage firm. The brokerage firm, in turn, assigns it to one (or more of their customers who wrote the option(s).

It is important to note that once an exercise notice is issued to a particular writer, the writer is not allowed to cancel out the position by using a closing transaction. Thus, the writer of an option always carries the risk that the option may be exercised and that he/she may be called upon to make a delivery. However, this does not pose a difficulty if the underlying asset is a share which is freely traded in the market.

Covered and Naked Calls

If the owner of a call decides to exercise the call, then the writer of the call has the obligation to sell the underlying asset to the call owner at the strike price. The writer of the call would receive an amount equal to the exercise price. The call writer might, or might not, be holding the underlying asset. If a call writer owns the asset underlying the call, he/she is said to have written a *covered call*. On the other hand, if a call is written where the writer does not have the asset underlying the call option, the call is said to be a *naked call*. In the event of a decision of the call owner to exercise the option in the latter case, the seller of the call has to buy the underlying asset at its prevailing market price and give it to the call owner. For a call option on a certain share, the required number of shares would be bought and delivered.

Similarly, when the put positions are opened, the put buyer gives the put premium to the put writer. If the owner of a put option chooses to exercise the option, the put writer is obliged to accept the underlying asset at the strike price.

Margin Requirements

As in the case of futures contracts, the performance of options contracts is also assured by the options exchanges (the OCC). When the buyer of an option enjoys the right of its performance on the exchange, the exchange has, in turn, to make sure that the contract will be honoured. Thus, for example, if I write a naked call, my broker would need a guarantee in some form that I would have the necessary funds to be able to deliver the asset, should the buyer of the option choose to exercise the call, and in turn assure the exchange of the performance of the contract. For this, *margin* requirements exist as a form of collateral to ensure that the writer of a naked call can fulfill the terms of the contract.

Accordingly, the writers of options are required to meet the margin requirements. The requirements vary depending upon the brokerage firm, the price of the underlying asset, the price of the option, and whether the option is a call or a put. As a general rule, initial margins are at least 30% of the stock price when the option is written, *plus* the intrinsic value of the option. The amount of margin has an influence on the degree of financial leverage that the investor has and, consequently, on the returns and risk on the position.

BUYER/SELLER ATTITUDES

Call buyers as bullish because they hope that the price of the underlying asset will increase. If you buy a call option on a share, with a strike price of Rs 150 per share, then you would be happy when the price increases to, say Rs 160, and happier when it rises to, say, Rs 180. Other things being equal, an option to buy the share at Rs 150 is obviously more valuable when it is selling at Rs 160 than when it is selling for Rs 150, and the higher the price beyond Rs 150, the more valuable would the call be. The call writer, who writes a naked call, expects the price of the underlying asset to fall. In such an event, the writer retains the premium as profit for undertaking to write the call.

In contrast to these, the put buyers are bearish—hoping that the price of the underlying asset would scale down—while the writers of the put options are bullish in nature. Put options are a waste when the market price of the asset exceeds the exercise price and so whereas the put buyers would like to see the prices falling, their writers like it the other way round.

OPTION PRICING

We have discussed earlier 'the' option price or the option premium. This is because, to begin with, we assumed that there are no transactions costs involved in trading in the options—whether buying or selling. In such a situation, an investor can buy or sell shares and options at a single price, without paying any commissions and buying/selling can be done instantaneously. In reality, however, at any time, there are two prices on an options—*bid* price and *ask* price, with the ask price being greater than the bid price. The bid price is the price at which one is prepared to buy an option while the ask (or asked) price is the price at which one is prepared to sell it. These prices are quoted by market makers, the exchange members who provide liquidity to the market. In case the market makers were not there, an investor proposing to sell options would have to wait until some buyer came along and proposed to buy the quantity offered at a suitable price. The market makers lend a great deal of liquidity by providing a continuous market to the buyers and sellers. The difference between the ask and bid prices is the *bid-ask spread*, which is the source of profit for the market makers.

By assuming that the options are bought and sold at a single price, we are assuming, in effect, that the bid-ask spread does not exist. There is another factor to be considered here. In a perfectly competitive market, it is possible to buy or sell *any* quantity of an asset at the ruling price without affecting the price. However, the options markets generally do not have the depth and liquidity to be perfectly competitive so that if a large quantity is sought to be bought/sold, it would affect the option price most likely. This is what is known as the *price pressure*.

Thus, reference to merely the price of an option is tantamount to implicitly assuming the absence of bid-ask spread and the existence of perfect competition in the options market. We return to a discussion on these concepts later.

Call Option at Expiration

If the price of the underlying asset is lower than the exercise price on the expiration of a call option, the call would expire unexercised. This is because no one would like to buy an asset which is available in the market at a lower price. If an out-of-the-money call did actually sell for a certain price, the investor can make an arbitrage profit by selling it and earning a premium. The buyer of the call is then unlikely to exercise this option, thus allowing the call seller to retain the premium. In the event of (an irrational) exercise of such a call, the call writer would buy the asset from the market at the prevailing price, S_1, and sell to the holder of the call at a rate of E, thereby making a profit of $E - S$, in addition to the call premium received earlier.

On the other hand, if the call happens to be in-the-money, it will be worth its intrinsic value, equal to the excess of asset price over the exercise price. If the call price happens to be lower than the intrinsic value, it will be profitable to buy the call at C, exercise it immediately, by paying an amount equal to E for the asset to be sold immediately in the market at a price of S_1 and thereby make a profit equal to $S_1 - E - C$, because $S_1 > E$, and $C < (S_1 - E)$. Similarly, if an in-the-money call option is selling at a value greater than the difference between the asset price and the exercise price, an arbitrage profit can be made by selling an option, buying the asset and, finally, delivering the asset on exercise.

Example 4.2

A call option involving 200 shares, due to mature, is selling for Rs 3.25 on a share which is selling in the market at Rs 66. The option has an exercise price equal to Rs 62.

Here, the call is priced lower than its intrinsic value. An arbitrageur may buy the call for 200 shares by paying Rs 650, exercise it and get the shares by paying Rs 12,400. The 200 shares may be sold immediately in the market to get Rs 13,200. It would yield a net profit of Rs 13,200 – Rs 12,400 – Rs 650 = Rs 150.

Example 4.3

Suppose that a call option involving 100 shares is selling for Rs 5.25 when the share price is Rs 64 and exercise price is Rs 60.

Here, an arbitrageur can sell the call on 100 shares to receive Rs 525 and buy the shares for Rs 6400. When the call, being in-the-money, is exercised, shares can be delivered for Rs 6000. This would result in an arbitrage profit of Rs 6000 + Rs 525 – Rs 6400 = Rs 125.

Thus the price of a call on expiration is a function of the share price at the expiration, S_1, and the exercise price, E. This is equal to zero when $S_1 \leq E$ and $S_1 - E$ when $S_1 > E$.

Put Option at Expiration

We may determine the value of a put option at expiration in a manner similar to that for a call option. Thus, when at expiration the price of the underlying asset is greater than the exercise price, the put will expire unexercised. This is because there is no point in exercising an option to sell, for instance, a share for, say Rs 65 when it is selling in the market for Rs 70. Thus, a rational investor would not exercise an out-of-the-money option. If such an option was indeed selling in the market for some price *P*, it is better for the holder to sell it and gain the cash flow. Further, if such an option was actually (irrationally, of course) exercised, it would benefit the seller of the call because he could pay *E* for the asset and sell it in the market for a higher price S_1. On the other hand, if a put option is in-the-money, then it must sell for $E - S_1$. Assuming that it was selling at a price higher than the difference between the exercise price and the asset price, then arbitrage profit could result. For example, suppose that a put option is selling at Rs 4.80, while the underlying share is priced at Rs 67 and the exercise price in the put is Rs 70. Now, an arbitrageur can sell an option for 100 shares and receive Rs 480, get the shares for Rs 7,000 when the option is exercised, sell the shares in the market at Rs 67 per share to receive a sum of Rs 6,700. This would result in a net gain of Rs 67,000 + Rs 480 − Rs 7,000 = Rs 180. If the market works perfectly, then no arbitrage opportunity would be possible and the put would be selling for no more than the difference between the exercise price and the stock price.

Thus the price of a put option on expiration is a function of the asset price at expiration, S_1, and the exercise price, *E*. This is equal to zero when $S_1 \geq E$ and $E - S_1$ when $S_1 < E$.

Figure 4.1 (a) illustrates that the price of a call option is nil when the stock price falls short of the exercise price *E*. This is reflected in the horizontal line to the left of *E*. When, however, the stock price (S_1) is greater than the exercise price, the call is worth $S_1 - E$. This shown by the line at 45 degrees.

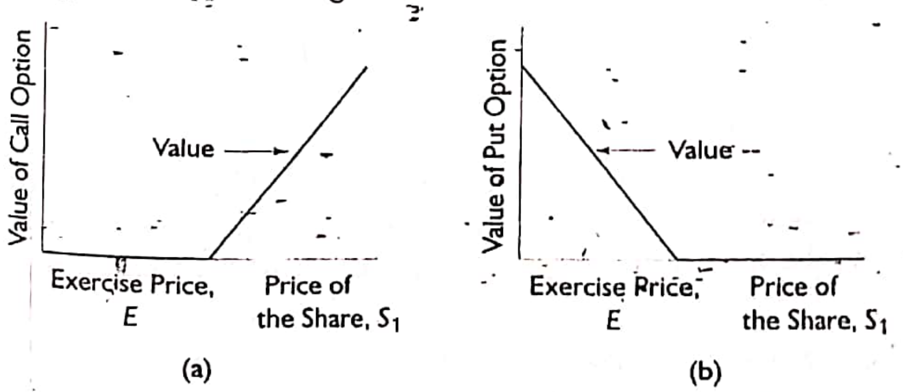


Fig. 4.1 *Call and Put Pricing at Expiration*

On the other hand, Fig. 4.1(b) shows the worth of a put option. This shows that a put option is worthless for the range of stock prices greater than *E*, the exercise price. For price below this, the worth of a put option equals the excess of exercise price over the share price.

Option Pricing before Expiration

Before the expiration, the options, whether call or put, are usually sold for at least their intrinsic values. They may, or may not, have any time value. We shall first briefly describe about the pricing of the call options and then about the pricing of the put options. A detailed discussion about the determination of the premia on options can be found in Chapter 5.

Call Options Pricing A call option will usually sell for at least its intrinsic value. (An exception to this may be a European call on a share that would trade ex-dividend prior to the date of expiry—if the amount of dividend be large, the call might sell for less than its intrinsic value.) To this would be added the time value, if any: longer the time to expiry, greater is the time value. Thus, the premium on a call option is a function of the exercise price, the stock price and the time to expiry. There are other factors also which affect the price of an option. They are:

1. Variability of the prices (i.e., the variance of the distribution of stock's returns) of the underlying share, called the *volatility*.
2. Interest rate and the dividend, if any, between the current date and the date of expiration.

While the direction of the impact of these factors on the price of an option can be visualized, the way they contribute and affect the price of call options will be examined in the Chapter 5. Models, like the Black and Scholes option pricing model, have been developed over time which not only attempt to determine the price of an option on the basis of some given data but also provide a tool to find how option values will change, given a small change in one of the parameters of the system while holding all of the other parameters constant.

The price of a call option at a time before expiry can be shown as given in Fig. 4.2. The figure gives the value of an option with a certain maturity and exercise price *E*. For stock price values greater than *E*, the intrinsic value is equal to the excess of stock price over the exercise price. Thus, the minimum value of an option (equal to its intrinsic value) is shown by a 45-degree line starting at *E*, so as to have a height at any point to the right of E, equal to the excess of stock price (S) over the exercise price (E).

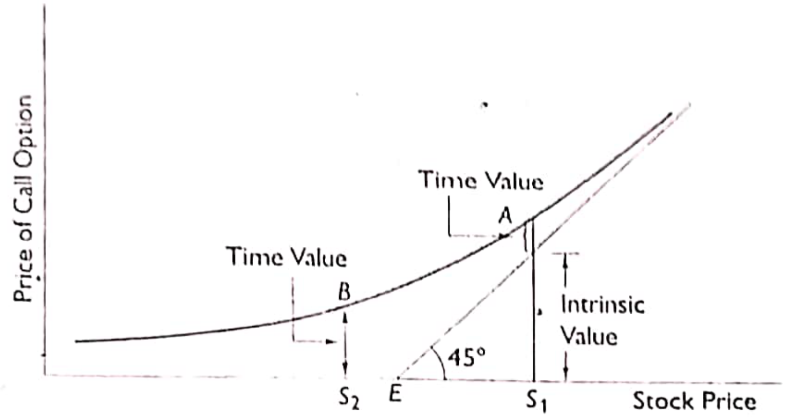


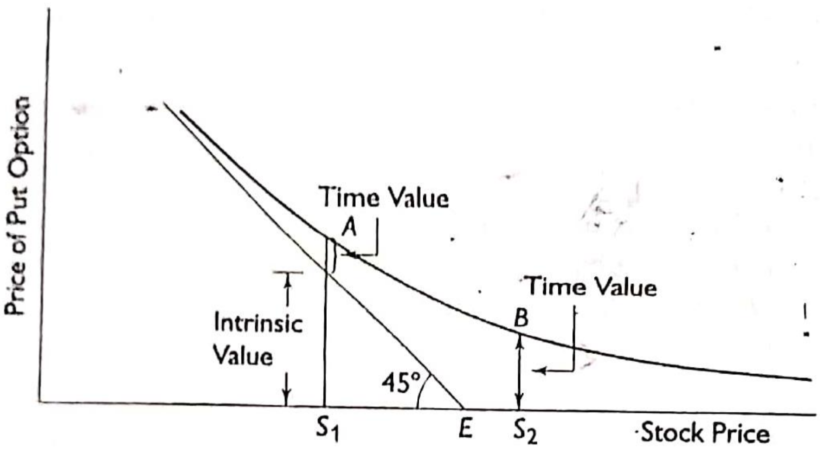
Fig. 4.2 *Call Option Pricing Before Expiration*

When the stock price is, say, S_1, the option price would be equal to S_1A—intrinsic value *plus* time value, as shown in the figure. On the other hand, if the share is priced at S_2, the call option is out-of-the-money and valued at S_2B, comprising only of the time value.

With all parameters remaining unchanged, if the time to maturity increases, then the curve showing the option value would shift upward.

Put Options Pricing Like a call option, a put option would sell for a price that is at least equal to its intrinsic value, which is the excess of exercise price over the stock price, when the option is in-the-money. For an in-the-money option, the premium is equal to the sum of the intrinsic value and the time value (which, in turn, is a function of the time to maturity). On the other hand, the at-the-money and out-of-the-money options have intrinsic value of nil and, accordingly, their prices are reflective of only the time value.

The price of a hypothetical put option with a certain time to maturity and an exercise price of E is depicted graphically in Fig. 4.3. The curve showing the price of the option is shown in the figure above the line depicting minimum value of the option price. This line, corresponding to the intrinsic value of the option is drawn at an angle of 45 degrees at point E, to the left of it. This is because the put option is in-the-money when $E > S$. As in the case of a call option, the put option premium is equal to the intrinsic value plus the time value. An out-of-the-money option, like the one when the stock price is S_2, has a premium comprising only of the time value.



➢ **Fig. 4.3** *Put Option Pricing Before Expiration*

RISK AND RETURN ON EQUITY OPTIONS

We may now discuss about the risk and return associated with equity options contracts. More details on risks of the parties to an option contract are given in Chapter 7. The analysis here is based on the following assumptions:

(i) The options are of the European style so that they cannot be exercised before the date of maturity.

(ii) The option positions are uncovered or naked. The buyer and the writer of an option contract are assumed not to have positions in the underlying stock.

(iii) There are no taxes and no transaction costs so that a position can be taken without incurring any cost. Consideration of transaction costs (brokerage fees, etc.) and taxes would obviously reduce the gains and increase the losses in a given situation.

First we consider the call options and then the put options.

Call Options

Consider a call option on a certain share, say *ABC*. Suppose the contract is made between two investors *X* and *Y*, who take, respectively, the short and long positions. The other details are given below:

Exercise price = Rs 120
Expiration month = March, 2003
Size of contract = 100 shares
Date of entering into contract = January 5, 2003

Price of share on the date of contract = Rs 124.50
Price of option on the date of contract = Rs 10

At the time of entering in to the contract,

Investor *X* writes a contract and receives Rs 1000 (= 10 × 100)

Investors *Y* takes a long position and pays Rs 1000 for it.

On the date of maturity, the profit or loss to each investor would depend upon the price of the share *ABC* prevailing on that day. The buyer would obviously not call upon the call writer to sell shares if the price happens to be lower than Rs 120 per share. Only when the price exceeds Rs 120 per share will a call be made. Having paid Rs 10 per share for buying an option, the buyer can make a profit only in case the share price would be at a point higher than Rs 120 + Rs 10 = Rs 130. At a price equal to Rs 130 a break-even point is reached. The profit/loss made by each of the investors for some selected values of the share price of *ABC* is indicated in Table 4.2.

Table 4.2

Profit/Loss Profile for the Investors—Call Option

Possible Price of ABC at Call Maturity (Rs)	*Investor X*	*Investor Y*
90	1000	– 1000
100	1000	– 1000
110	1000	– 1000
120	1000	– 1000
130	0	0
140	– 1000	1000
150	– 2000	2000
160	– 3000	3000

The profit profile for this contract is indicated in Fig. 4.4. Figure 4.4 (a) shows the profit/loss function for the investor *X*, the writer of the call, while Fig. 4.4 (b) gives the same for the other investor *Y*, the buyer of the option. It is evident that the call writer's profit is limited to the amount of call premium but, theoretically, there is no limit to the losses if the stock price continues to increase and the writer does not make a closing transaction by purchasing an identical call. The situation is exactly opposite for the call buyer for whom the loss is limited to the amount of premium paid. However, depending on the stock price, there is no limit on the amount of profit which can result for the buyer. Being a 'zero-sum' game, a loss (gain) to one party implies an equal amount of gain (loss) to the other party.

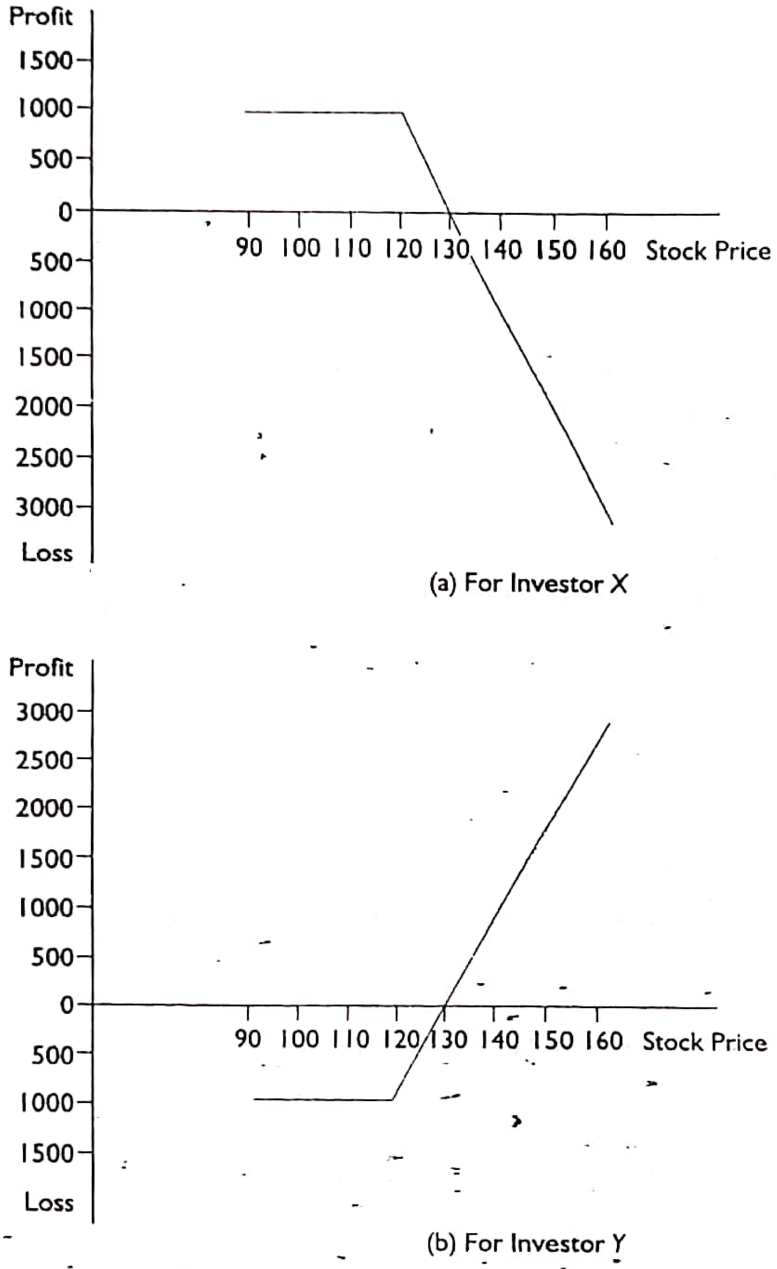


Fig. 4.4 *Profit Functions: Call Option*

Put Options

In a put option, since the investor with a long position has a right to sell the stock and the writer is obliged to buy it at the will of the buyer, the profit profile is different from the one in a call option where the rights and obligations are different.

Consider a put option contract on a certain share, *PQR*. Suppose, two investors *X* and *Y* enter into a contract and take short and long positions respectively. The other details are given below:

Exercise price = Rs 110
Expiration month = March, 2003
Size of contract = 100 shares
Date of entering into contract = January 6, 2003
Share price on the date of contract = Rs 112
Price of put option on the date of contract = Rs 7.50

Now, as the contract is entered into, the writer of the option, *X*, will receive Rs 750 (= 7.50 × 100) from the buyer, *Y*. At the time of maturity, the gain/loss to each party depends on the ruling price of the share. If the price of the share is Rs 110 or greater than that, the option will not be exercised, so that the writer pockets the amount of put premium—the maximum profit which can accrue to a seller. At the same time, it represents the maximum loss that the buyer is exposed to. If the price of the share falls below the exercise price, a loss would result to the writer and a gain to the buyer. The maximum loss that the writer may theoretically be exposed to is limited by the amount of the exercise price. Thus, if the value of the underlying share falls to zero, the loss to the writer is equal to Rs 110 – Rs 7.50 = Rs 102.50 per share. The profit/loss for some selected values of the share are given in Table 4.3.

The break-even share price would be Rs 102.50 (= Rs 110 – Rs 7.50). If the price of the share happens to be lower than this, the writer would make a loss—and the buyer makes a gain. For instance, when the price of the share is Rs 100, the gain/loss for each of the investory may be calculated as shown below.

Investor X

Option premium received = 7.5 × 100 = Rs 750
Amount to be paid for shares = 110 × 100 = Rs 11,000
Market value of the shares = 100 × 100 = Rs 10,000
Net Profit(Loss) = 750 – 11,000 + 10,000 = (Rs 250)

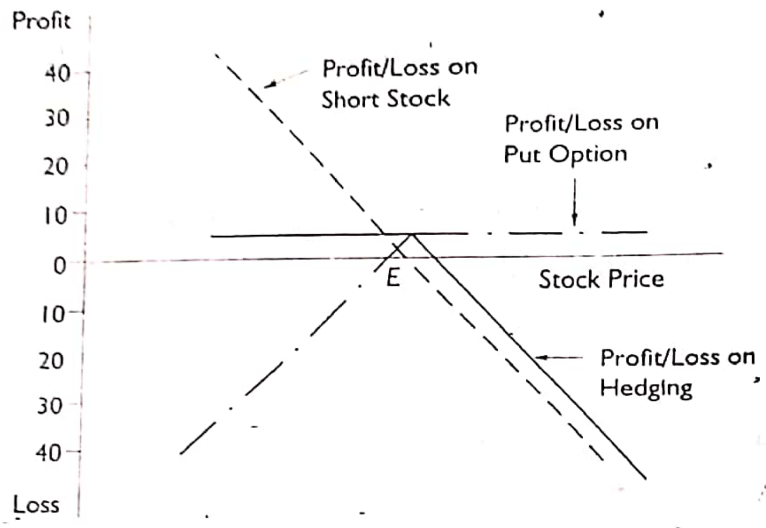


Fig. 4.9 *Hedging: Short Stock Short Put*

Spreads and Combinations

As indicated earlier, options can be combined in several ways— multiple calls, multiple puts or calls and puts together. We shall discuss some of the more generally used combinations.

Spreads A spread trading strategy involves taking a position in two or more options of the same type.

Bull Spreads One of the most popular spread strategies is a bull spread. A bull spread reflects the bullish sentiment of a trader and can be created by purchasing a call option on a stock and selling another call on the stock and with the same expiry but a higher exercise price. At expiry, if the stock remains below the lower strike price, both calls would expire unexercised and the loss will be limited to the initial cost of the spread. It may be recalled that other things remaining the same, a call with a lower exercise price has a greater premium. Accordingly, the price payable for buying a lower exercise price options is more than the premium receivable from writing an option with a greater exercise price and, hence, a cost is involved in buying the spread.

Further, if the stock price rules between the strike prices of the two calls, the purchased call is in-the-money while the call sold expires unexercised. Thus, the payoff equals the difference between the stock price and the (lower) exercise price. If the stock price is greater than the higher exercise price, both options are in-the-money and the payoff equals the difference between the exercise prices of the two options. To illustrate this, suppose that you buy a call option with an exercise price of Rs 50 for Rs 8 and sell one with an exercise price of Rs 60 for a premium of Rs 2, both being on the same stock and with same expiration date. Now if the price rules at Rs 50 or less, none of them would be exercised, with the result that the payoff will be nil and the net loss would be Rs 6 (Rs 8 – Rs 2). If the price of stock at the time of exercise is, say, Rs 58, then the call with an exercise price of Rs 50 shall be exercised for a payoff of Rs58 – Rs 50 = Rs 8, the net profit being Rs 8 – Rs 8 + Rs 2 = Rs 2. Finally, if the price of the stock is higher than Rs 60, both of these will be exercised and the payoff would be Rs 60 – Rs 50 = Rs 10 with the net profit equal to Rs 10 – Rs 2 = Rs 8. The payoff function for a bull spread described above is shown in Fig. 4.10, where E_1 and E_2 are the respective exercise prices of the twin calls.

The payoffs resulting from a bull spread strategy are given in Table 4.8. While E_1 and E_2 are the respective strike prices of the calls that are long and short, S_1 represents the stock price at the time of exercising the calls.

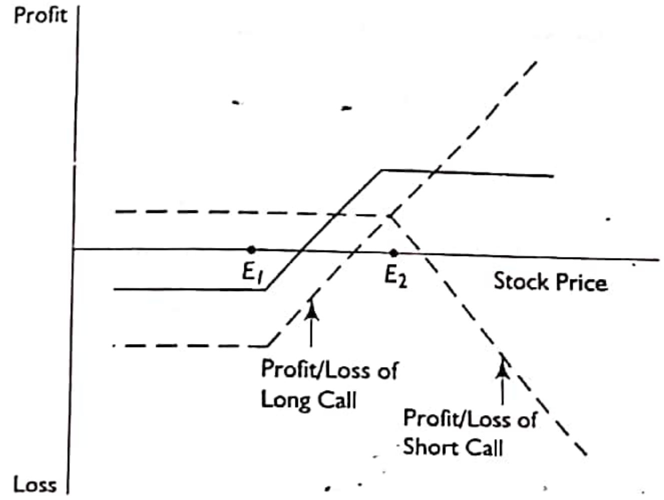
Table 4.8

Payoffs from a Bull Spread (Using Calls)

Price of Stock	*Payoff from Long Call*	*Payoff from Short Call*	*Total Payoff*
$S_1 \geq E_2$	$S_1 - E_1$	$E_2 - S_1$	$E_2 - E_1$
$E_1 < S_1 < E_2$	$S_1 - E$	0(NE*)	$S_1 - E_1$
$S_1 \leq E_1$	0(NE)	0(NE)	0

*Note: * NE: Not exercised.*

Thus, by selling a call against an otherwise naked all, the investor in a bull spread sacrifices an unlimited profit potential in return for the initial cost. If both the calls are initially out-of-the-money, then a small cost would be involved in creating the spread which would be aggressive in nature. A less bullish investor would buy an in-the-money spread for lower gearing. A spread with one call initially in-the-money and the other one initially out-of-the-money would be relatively less aggressive than a spread with both calls being out-of-the-money, while a spread created with both calls being in-the-money initially would be the most conservative.



➢ **Fig. 4.10** *Bull Spread (Using Calls)*

A bull spread can also be created using puts. One put is purchased and another one is sold which is on the same stock, with the same expiry date but with a higher exercise price. On expiry, if the stock remains below the lower exercise price, both options are exercised and the position is closed for the difference between the two exercise prices. This results in an overall loss of the initial credit (higher premium received on short put minus lower premium paid on long put) *minus* the difference. If the stock price is between the two exercise prices, the put with the lower exercise price would expire unexercised resulting in a net profit equal to the initial credit *minus* the difference between the exercise price and the stock price. For the stock prices exceeding the higher exercise price, both puts expire unexercised leading to no payoffs and a net profit equal to the initial credit.

Suppose an investor buys a put option with an exercise price equal to Rs 40 for Rs 6 and writes an option identical in all respects except the exercise price that is equal to Rs 50, for a price of Rs 9. This spread gives an initial credit of Rs 3. Now, if the stock price is less than Rs 40, then both options are in-the-money and can be exercised. A commitment to buy at Rs 50 and to sell at Rs 40 implies an outward payoff of Rs 10 and a net loss equal to Rs 10 – Rs 3 = Rs 7. For a stock price in between the two exercise prices, say Rs 44, the investor has to buy the stock at Rs 50 and thus lose Rs 6 on the option. In this case, the net loss would equal Rs 6 – Rs 3 = Rs 3. Similarly, when the stock price would be more than Rs 50, none of the options will be exercised and a net profit of Rs 3 will be made.

In general, the profit function is as shown in Fig. 4.11. The payoffs associated with a bull spread created using put options are given in Table 4.9. The stock price at the time of exercise is given by S_1 and the two options have exercise prices of E_1 and E_2 ($E_2 > E_1$).

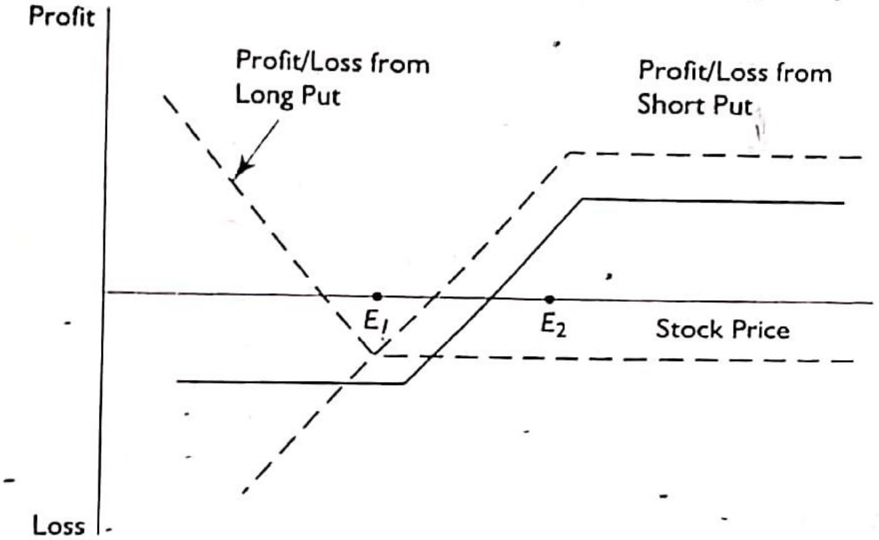


Fig. 4.11 *Bull Spread (Using Puts)*

Table 4.9

Payoffs from a Bull Spread (with Puts)

Stock Price	*Payoff from Long Put Option*	*Payoff from Short Put Option*	*Total Payoff*
$S_1 \le E_1$	$E_1 - S_1$	$S_1 - E_2$	$E_1 - E_2$
$E_1 < S_1 < E_2$	0	$S_1 - E_2$	$S_1 - E_2$
$S_1 \ge E_2$	0	0	0

Bear Spreads In contrast to the bull spreads, bear spreads are used as a strategy when one is bearish on the market, believing that it is more likely to go down than up. Like a bull spread, a bear spread may be created by buying a call with one exercise price and selling another one with a different exercise price. Unlike in a bull spread, however, the exercise price of the call option purchased is higher than that of the call option sold. A bear spread would involve an initial cash inflow since the premium for the call sold would be greater than for the call bought. Assuming that the exercise prices are E_1 and E_2, with $E_1 < E_2$, the payoffs realizable from a bear spread in different circumstances are given in the Table 4.10. The profit profile is shown in Fig. 4.12.

Suppose that the exercise prices of two call options are Rs 50 and Rs 60. If the stock price, S_1, be lower than Rs 50, then none of the calls will be exercised and, therefore, no payoffs are involved. If the price were between the two exercise prices, say Rs 57, then the call written for Rs 50 would be exercised and the investor loses Rs 7, and if the price of the stock exceeded Rs 60, both the calls would be exercised and an outward payoff of Rs 10 would result. In each of the cases, the net profit would be obtained by adjusting for the initial cash inflow.

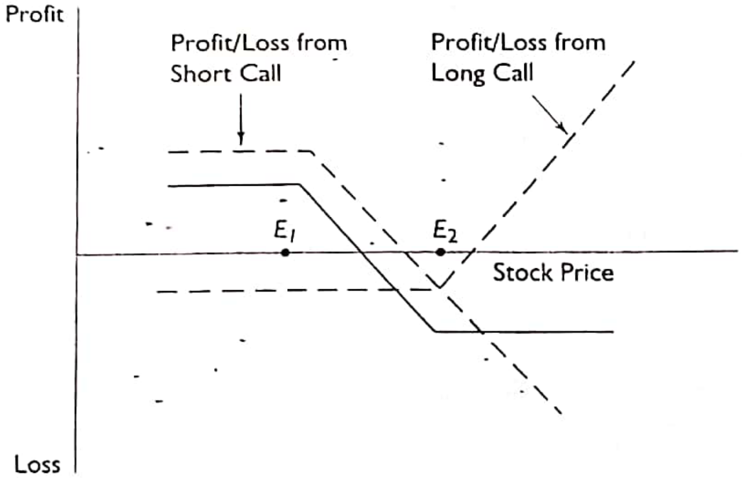


Fig. 4.12 *Bear Spread (Using Calls)*

Table 4.10

Payoffs from a Bear Spread (Using Calls)

Stock Price	*Payoff from Long Call Option*	*Payoff from Short Call Option*	*Total Payoff*
$S_1 \geq E_2$	$S_1 - E_2$	$E_1 - S_1$	$E_1 - E_2$
$E_1 < S_1 < E_2$	0	$-E_1 - S_1$	$E_1 - S_1$
$S_1 \geq E_2$	0	0	0

Bear spreads can also be created by using put options instead of call options. In such a case, the investor buys a put with a high exercise price and sells one with a low exercise price. This would require an initial investment because the premium for the put with a higher exercise price would be greater than the premium receivable for the put with the lower exercise price, written by the investor. In this spread, the investor buys a put with a certain exercise price and chooses to give up some of the profit potential by selling a put with a lower exercise price. In return for the profit given up, the investor gets the price of the option sold.

The payoffs from a bear spread created with put options are given in Table 4.11 where in E_1 and E_2 are the exercise prices of the options sold and purchased respectively. The profit function is given in Fig. 4.13. It may be observed that, like bull spreads, bear spreads limit both the upside profit potential and the downside risk.

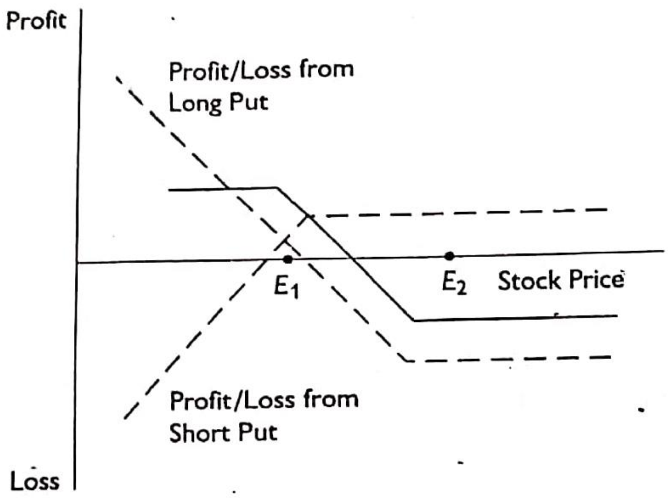


Fig. 4.13 *Bear Spread (Using Puts)*

Table 4.11

Payoffs from a Bear Spread (Using Puts)

Stock Price	*Payoff from Long Put*	*Payoff from Short Put*	*Total Payoff*
$S_1 \geq E_2$	0	0	0
$E_1 < S_1 < E_2$	$E_2 - S_1$	0	$E_2 - S_1$
$S_1 \leq E_1$	$E_2 - S_1$	$S_1 - E_1$	$E_2 - E_1$

Example 4.4

For each of the following cases, name the strategy adopted and calculate the profit/loss for different price ranges of the stock taking $S_1 \geq E_2$, $E_1 < S_1 < E_2$ and $S_1 \leq E$. Also, determine the break-even stock price in each case.

Type of Option	*Exercise Price of Option*		*Premium on Option*	
	Purchased (Rs)	*Sold (Rs)*	*Purchased (Rs)*	*Sold (Rs)*
I. Call	60	75	10	4
II. Call	80	70	5	11
III. Put	70	60	9	5
IV. Put	50	65	4	11

I. Buying a call with lower exercise price and selling a call with a greater exercise price results in *bull spread.* With price of long call, $E_1 = 60$ and price of a short call, $E_2 = 75$, the profit/loss would be as follows:

Stock Price	Payoff from Long Call	Payoff from Short Call	Total Payoff	Net Profit/Loss = Payoff-Cost
$S_1 \geq E_2$	$S_1 - 60$	$75 - S_1$	15	$15 - 6 = 9$
$E_1 < S_1 < E_2$	$S_1 - 60$	0	$S_1 - 60$	$S_1 - 60 - 6 = S_1 - 54$
$S_1 \leq E_1$	0	0	0	$0 - 6 = -6$

The break-even stock price would be one where net profit is equal to zero. Accordingly, $S_1 - 54 = 0$ or $S_1 = 54$. Thus, a stock price greater than Rs 54 would yield profit.

II. Buying a call with a higher exercise price and selling a call with a lower exercise price is a *bear spread* strategy. Here E_1 is the price of call sold and E_2 is the price of the call purchased. Thus, $E_1 = 70$ and $E_2 = 80$. Net premium obtained = 11 – 5 = Rs 6. The profit/loss would be as shown below:

Stock Price	Payoff from Long Call	Payoff from Short Call	Total Payoff	Net Profit/Loss = (Payoff+ Net Premium)
$S_1 \geq E_2$	$S_1 - 80$	$60 - S_1$	– 20	$-20 + 6 = -14$
$E_1 < S_1 < E_2$	$70 - S_1$	0	$70 - S_1$	$70 - S_1 + 6 = 76 - S_1$
$S_1 \leq E_1$	0	0	0	$0 + 6 = 6$

To determine break-even stock price, we set $76 - S_1 = 0$. Thus, $S_1 = 76$. Therefore, a stock price below Rs 76 would yield profit, while for stock prices above this level losses would result.

III. The sale of a lower exercise price put option and purchase of a higher value put option is also a *bear spread* strategy. With $E_1 = 60$ and $E_2 = 70$, and a net cost of Rs 4 (= Rs 9 – Rs 5), the profit/loss profile is as given below.

Stock Price	Payoff from Long Put	Payoff from Short Put	Total Payoff	Net Profit /Loss
$S_1 \geq E_2$	0	0	0	$0 - 4 = -4$
$E_1 < S_1 < E_2$	0	$60 - S_1$	$60 - S_1$	$60 - S_1 - 4 = 56 - S_1$
$S_1 \leq E_1$	$70 - S_1$	$S_1 - 60$	10	$10 - 4 = 6$

For the break-even price, $56 - S_1 = 0$. Thus, $S_1 = 56$. With stock prices below Rs 56, profit will result, while loss will result with prices greater than this.

IV. Buying a put option with exercise price equal to Rs 50 and selling a put option with a greater exercise price of Rs 65 represents a *bull spread.* This would result in a positive cash flow of Rs 11 – Rs 4 = Rs 7 to the investor up front. The profit/loss position is as given below.

Stock Price	Payoff from Long Put	Payoff from Short Put	Total Payoff	Net Profit/Loss
$S_1 \geq E_2$	0	0	0	$0 + 7 = 7$
$E_1 < S_1 < E_2$	0	$S_1 - 65$	$S_1 - 65$	$S_1 - 65 + 7 = S_1 - 58$
$S_1 \leq E_1$	$50 - S_1$	$S_1 - 65$	-15	$-15 + 7 = -8$

To obtain the break-even price, we set $S_1 - 58 = 0$, so that, $S_1 = 58$, implying that a profit would result when the stock price exceeded Rs 58 and a loss would be incurred when it fell short of Rs 58.

Butterfly Spreads While bull and bear spreads involve taking positions in two options, a butterfly spread results from positions in options with three different strike prices. This involves buying a call option with a relatively low exercise price, E_1, buying another call option with a relatively large exercise price, E_3, and selling two call options with a strike price, E_2 which is halfway between E_1 and E_3. The price E_2 is usually close to the current stock price, with the result that a profit results if the stock price stays close to E_2 and a small loss would be incurred if there is a significant price movement either way from it. The strategy is obviously meant for an investor who feels that large price changes are unlikely. The positions taken in the strategy involve some cost.

If E_1, E_2 and E_3 be Rs 50, Rs 60 and Rs 70 respectively, and the stock price be less than Rs 50, then, clearly, no call will be exercised. Accordingly, the total loss equals the initial cost involved. Similarly, beyond Rs 70, when *all* calls will be exercised, the total loss equals the initial cost, because the gain on the options with long position will be exactly offset by a corresponding loss on the twin options written. Gain would result when the stock price is between Rs 50 and Rs 60, and shall be higher as the price moves towards Rs 60. Beyond this price, the amount of gain would decline with an increase in the stock price up to the level of Rs 70. The payoffs for a butterfly spread are given in Table 4.12. The profit/loss profile for a butterfly spread is given in the Fig. 4.14.

Example 4.5

A certain stock is selling currently at Rs 72. An investor, who feels that a significant change in this price is unlikely, in the next three months, observes the market prices of 3-month calls as tabulated below:

Exercise Price	Call Price (Rs)
65	11
70	8
75	6

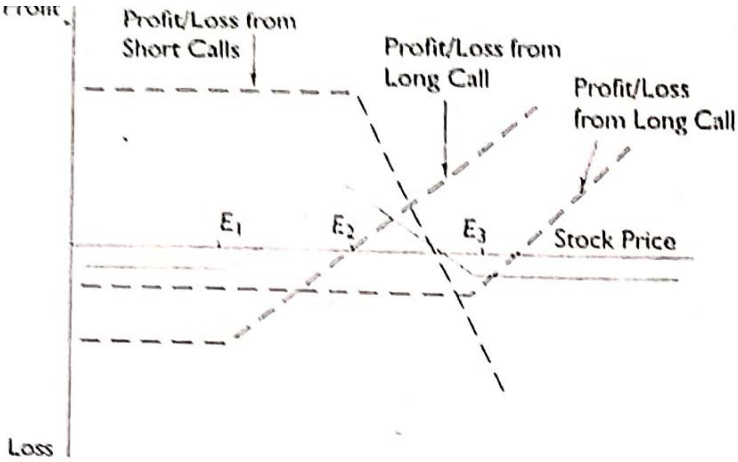


Fig. 4.14 *Butterfly Spread*

Table 4.12

Payoffs from a Butterfly Spread

Stock Price	*Payoff from First Long Call-(E_1)*	*Payoff from Second Long Call (E_3)*	*Payoff from Short Calls (E_2)*	*Total Payoff*
$S_1 < E_1$	0	0	0	0
$E_1 \le S_1 < E_2$	$S_1 - E_1$	0	0	$S_1 - E_1$
$E_2 \le S_1 < E_3$	$S_1 - E_1$	0	$2(E_2 - S_1)$	$E_3 - S_1^*$
$S_1 \ge E$	$S_1 - E_1$	$S_1 - E_3$	$2(E_2 - S_1)$	0

* $S_1 - E_1 + 2E_2 - 2S_1 = 2E_2 - E_1 - S_1$, or $E_3 - S_1$ Since $2E_2 = E_3 + E_1$

The investor decides to go long in two calls—one each with exercise price Rs 65 and Rs 75—and writes two calls with an exercise price of Rs 70. Determine his payoff function for different levels of stock prices. Also, find his profit/loss when the stock price at maturity is (i) Rs 63, (ii) Rs 68, (iii) Rs 73, and (iv) Rs 80.

The decision of the investor leads to a *butterfly spread*. Buying two calls involves a payment of Rs 11 + Rs 6 = Rs 17, and writing two calls yields Rs 8×2 = Rs 16. Thus, cost involved with the package of options = Rs 17 – Rs 16 = Re 1. The payoffs associated with this plan are given in Table 4.13.

From the table, it is clear that when the stock price is less than Rs 65, or Rs 75 and above, the payoff will be nil, while if the price varied between Rs 65 and Rs 70, the payoff equal to the price in excess of Rs 65 and if it is in the range of Rs 70 to Rs 75, then the payoff is Rs 75 minus the stock price. Accordingly, profit/loss can be calculated for various given prices as follows.

Table 4.13

Payoffs from a Butterfly Spread

Stock Price	Payoff from first Long Call ($E_1 = 65$)	Payoff from second Long Call ($E_3 = 75$)	Payoff from two Short Calls ($E_2 = 70$)	Total Payoff
$S_1 < 65$	0	0	0	0
$65 \le S_1 < 70$	$S_1 - 65$	0	0	$S_1 - 65$
$70 \le S_1 < 75$	$S_1 - 65$	0	$2(70 - S_1)$	$75 - S_1$
$S_1 \ge 75$	$S_1 - 65$	$S_1 - 75$	$2(70 - S_1)$	0

No.	Price	Total Payoff from Calls	Cost of Strategy	Net Profit/Loss
1	63	0	(1)	(1)
2	68	3	(1)	2
3	73	2	(1)	1
4	80	0	(1)	(1)

Combinations While spreads involve taking positions in call or put options only, combinations represent option trading strategies which involve taking positions in both calls and puts on the same stock. Important combination strategies include straddles, strips, straps, and strangles.

Straddle A straddle involves buying a call and a put option with the same exercise price and date of expiration. Since a call and a put are both purchased, it costs to buy a straddle and, to that extent, a loss is incurred if the price does not move away from the exercise price since none of them will be exercised. From the profit function depicted in Fig. 4.15, it is evident that buying a straddle is an appropriate strategy to adopt when large price changes are expected in the stock—for lower prices of the stock, the put option will be exercised and for higher prices, the call option will be exercised.

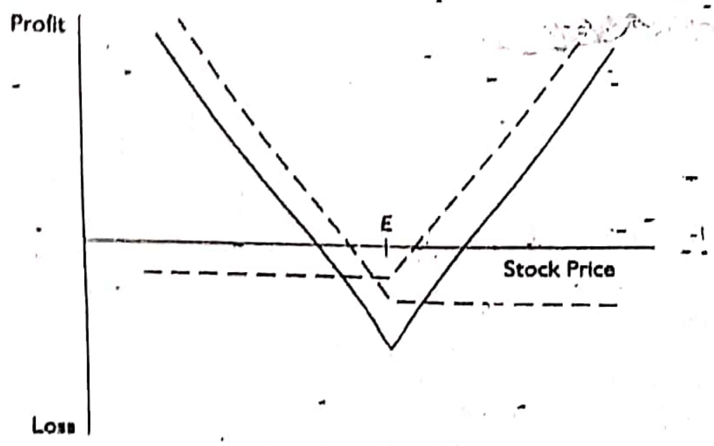


Fig. 4.15 *Straddle*

Suppose an investor feels that the price of a certain stock, currently valued at Rs 85 in the market, is likely to move significantly, upward or downward, in the next three months. The investor can create a straddle by buying a call and a put option both with an exercise price of Rs 85 and an expiration date in three months. Suppose that the call costs Rs 4 and the put Rs 2. Now, if the stock price at expiration is Rs 85, then none of the options will be exercised and a loss of Rs 6 would occur. If the stock price jumps to Rs 100, then the call will be exercised resulting in a net profit of (Rs 100 – Rs 85) – Rs 6 = Rs 9, while if the price falls to, say, Rs 57 then the put option will be exercised and a net profit of Rs (Rs 85 – Rs 57) – Rs 6 = Rs 22 will result. The payoffs in respect of a straddle are given in Table 4.14.

Table 4.14

Payoffs from a Straddle

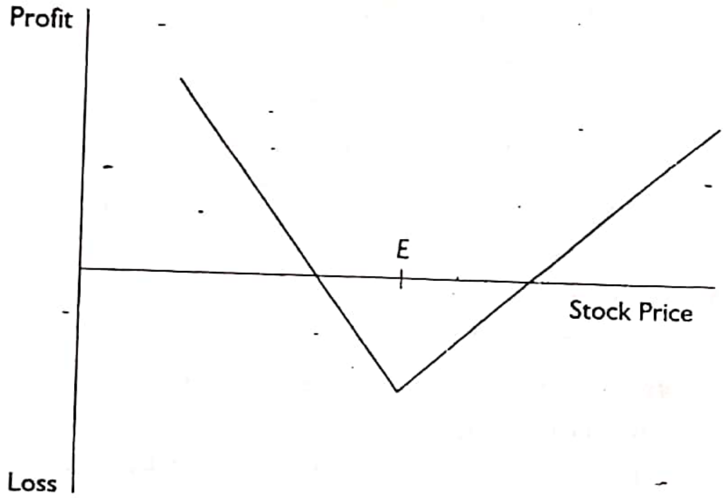
Exercise Price Range	*Payoff from Call Option*	*Payoff from Put Option*	*Total Payoff*
$S_1 \leq E$	0	$E - S_1$	$E - S_1$
$S_1 > E$	$S_1 - E$	0	$S_1 - E$

This kind of strategy is an obvious one to employ in respect of the stock of a company which is subject to a takeover bid.

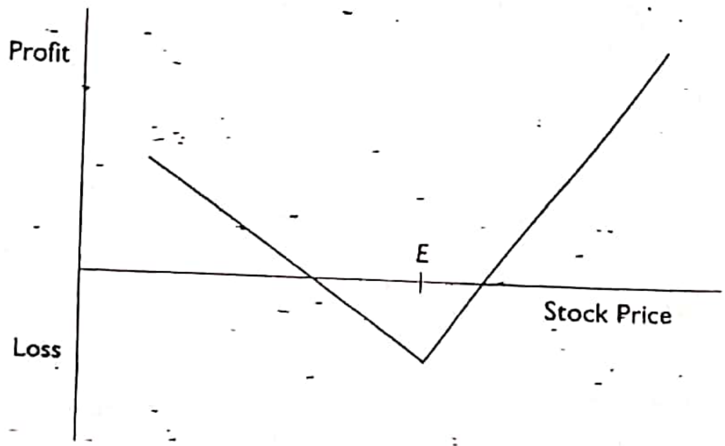
The straddle shown in Fig. 4.15 is an example of a *straddle purchase*. This is also referred to as a *bottom straddle*. A *straddle write*, or a *top straddle* represents the reverse position so that it may be created by selling a call and a put with the same expiration date and exercise price. In a straddle write, a significant profit is made if the stock price is equal to, or close to the exercise price, but large deviations of stock price from this on either side would cause large losses, which are potentially unlimited. Hence, a straddle write is a very risky strategy to adopt.

Strips and Straps Like straddles, strips and straps also involve taking long or short positions in calls and puts. A *strip* results when a long position in one call is coupled with a long position in two puts, all with the same exercise price and date of expiration. Here the investor is expecting that a big price movement in the stock price will take place but a decrease in the stock price is more likely than an increase. Since a put option is profitable when a price decrease occurs, two puts are bought in this strategy. Accordingly, the profit function for the strategy, shown in Fig. 4.16 is more steep in the lower than exercise price range and less steep in the region of higher prices.

On the other hand, if the investor is expecting that a big price change would occur in the stock price but feels that there is a greater likelihood of the price increasing rather than decreasing, the investor will consider the strategy of a strap. A *strap* consists of a long position in two calls and one put with the same exercise price and expiry date. The profit function for a strap is depicted in Fig. 4.17. The right to the exercise position of the profit function has a greater steepness than the other part.



> **Fig. 4.16** *Strip*



> **Fig. 4.17** *Strap*

Strangles In a strangle, an investor buys a put and a call option with the same expiration date but with different exercise prices. The exercise price of the put is lower than the exercise price of the call, so that a profit would result if the stock price is lower than the exercise price of the put or if the stock price exceeds the call exercise price. Between the two exercise prices, none of the options is exercised and hence, a net loss, equal to the sum of the premia paid for buying the two options, results. It follows, then, that a strangle is an appropriate strategy for adoption when the price is expected to move sharply. The profit function, for exercise price E_1 and E_2 of put and call respectively, is shown in Fig. 4.18 and payoffs for different ranges of the stock price are given in Table 4.15.

Table 4.15

Payoff from a Strangle

Price of Stock	*Payoff from Put*	*Payoff from Call*	*Total Payoff*
$S_1 \leq E_1$	$E_1 - S_1$	0	$E_1 - S_1$
$E_1 < S_1 < E_2$	0	0	0
$S_1 \geq E_2$	0	$S_1 - E_2$	$S_1 - E_2$

Evidently, a strangle is a similar strategy to a straddle, because here as well the investor is betting that a large price change would take place but is not sure as to the direction in which the change would occur. However, in a strangle, the stock price has to move father, than in a straddle, in order that the investor makes a profit. Also, if the stock price happens to be between the two exercise prices, the downside risk is smaller with a strangle than it is with a straddle if the price is close to the exercise price.

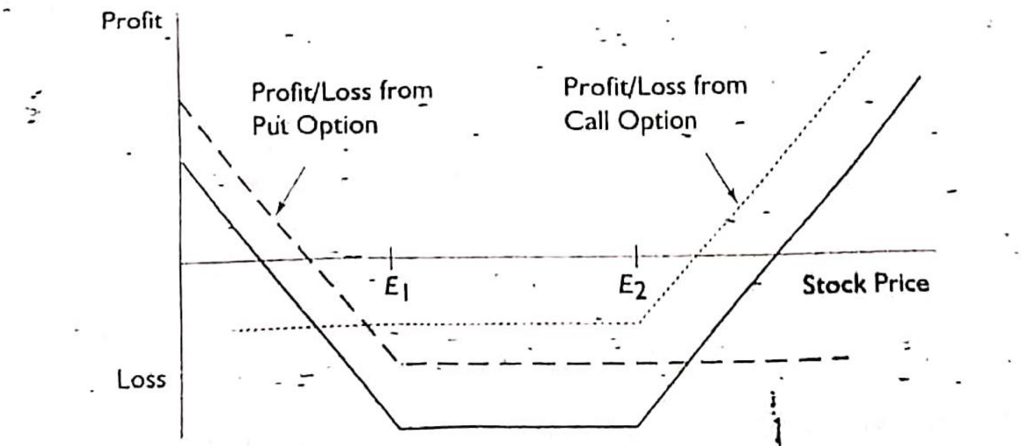


Fig 4.18 *Strangle*

Valuation of Options

In this chapter, we explore how trading prices of call and put options are determined. In this context, we will consider some models which have been put forth for assessing the prices of these assets. Various factors affecting the prices are also examined as the interrelationships between the prices of calls and puts.

As with other securities, the option premium, or the price, is determined competitively on the floor of the options exchange by the influx of buy and sell orders. It is influenced by a number of factors, some of which are listed below:

1. Price of underlying security.
2. Volatility.
3. Length of time to expiration.
4. Interest rates.
5. Tax rules with regard to gains and losses arising from option trading.
6. Margin-requirements in case of uncovered option writers.
7. Transaction cost.

While some formal models are available for the valuation of options, it will be instructive to first examine the manner in which certain characteristics of options are likely to affect option values in a rational market. These characteristics are useful for counter checking the option values derived by using valuation models.

European vs American Calls It may be recalled that a European call gives its holder the right to buy stock at the exercise price on a particular date and, therefore, can be exercised only at the expiration date, while an American call can be exercised at *any time up to* the expiration date. Obviously, since an American call provides an added opportunity, its value has to be at least equal to that of a European call with the same inputs. Accordingly, as a first relationship, it may be noted that a European call with the same expiration date and exercise price as an American call cannot sell for more than the latter.

Exercise Price If we consider two calls on a stock with the same expiration date, but with different exercise prices, then the call with a higher exercise price cannot be more valuable than the one with the lower exercise price. For example, suppose two calls on a share with identical expiration dates have exercise prices of Rs 110 and Rs 120. The holder of the former call can buy the share at Rs 110, and can be in the same position as the holder of the other call who could buy the same security at Rs 120, as also the cash left over. Obviously, then, the call with a higher exercise price cannot be expected to be valued higher.

Length of Time to Expiration In case of two calls on a stock with identical exercise prices but with different expiration dates, it can readily be seen that the one with a longer time to maturity would offer the investor with all the exercise opportunities as that of the one with a shorter life, and some additional opportunities. Accordingly, it may be reasonably expected that of the two composite calls, the one with a longer life cannot be valued lower than the one with a shorter life.

Now, let us turn to the valuation of options. We first consider a graphic approach and then the models of valuation.

A GRAPHIC ANALYSIS OF CALL AND PUT VALUES

A convenient way to examine call and put values is by way of profit/loss graphs (See Figs 5.1 and 5.2) which reflect the effect of the price of the underlying asset (here the asset is considered to be a stock) on option prices.

Call Option

Figure 5.1 illustrates a call option. A call cannot have a value greater than the value of the stock itself because of the exercise price. Obviously, it makes no sense to purchase an "option to buy" a share,

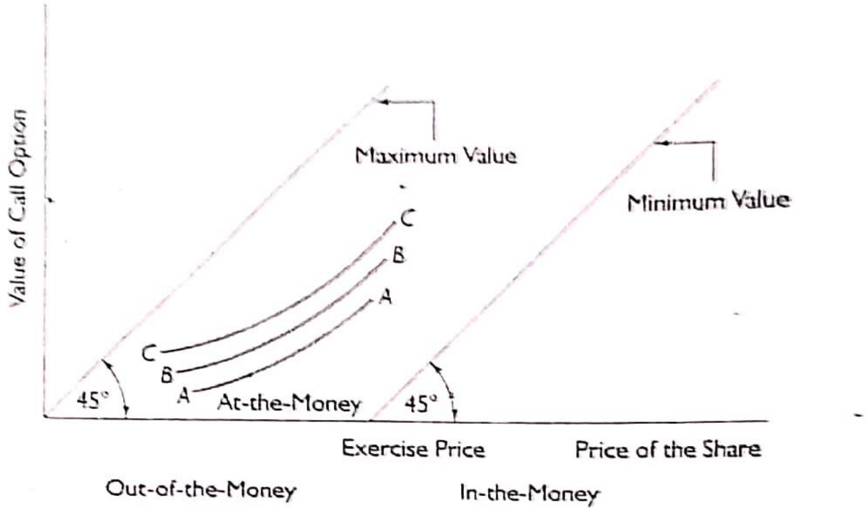
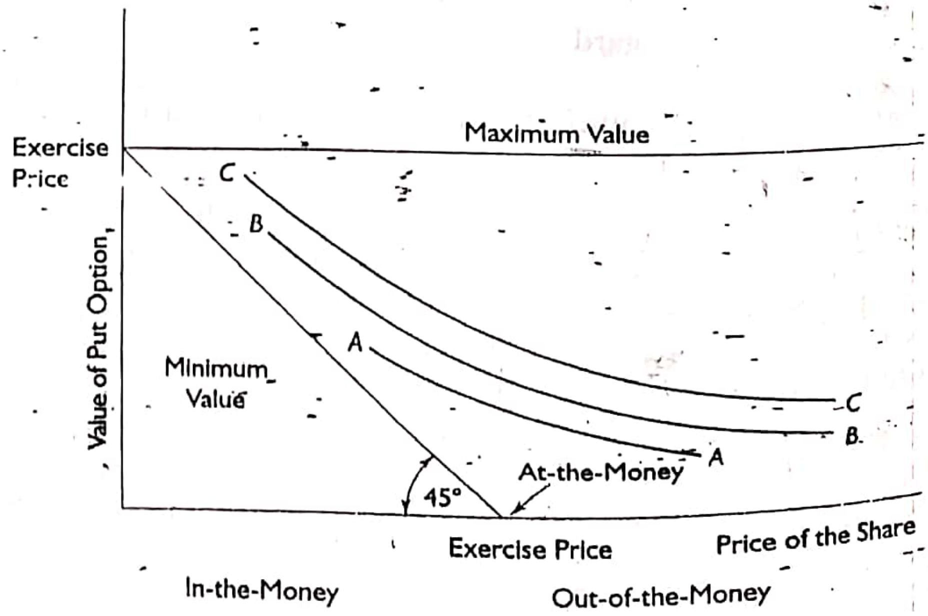


Fig. 5.1 *Call Option Values*

which is selling at Rs 200, for more than Rs 200. Thus, the stock price provides the upper bound on the value of a call option. Similarly, a call option cannot have a value smaller than its intrinsic value, where the intrinsic value is equal to the difference between the price of the stock and the exercise price (To be precise, it should be the *present value of the exercise price*. Here it is taken to be the exercise price merely for the sake of simplicity.) Thus, if a certain share is selling for Rs 50 and the exercise price is Rs 45, then it will have a maximum value of Rs 50 and a minimum value of $(S_0 - E)$ or Rs 50 – Rs 45 = Rs 5, since the call is in-the-money. For this share, if the call were at-the-money or out-of-money, its intrinsic value would be zero. Now, if the price of the share were to rise to Rs 52, then the value of the call should at least be equal to Rs 52 – Rs 45 = Rs 7, while this value would be a minimum of Rs 10 if the share price shot up to Rs 55. Thus, for an other than at or out-of-the-money call with a given exercise price, every rupee increase in the share value will lead to a corresponding increase in the call price. Accordingly, the maximum value line in Fig. 5.1 is drawn at an angle of 45 degrees from the origin, while the minimum value line is drawn at a 45-degree angle from the exercise price. Thus, a call option with a given exercise price will have a value on or above the minimum value function. Also shown in the figure are hypothetical functions *AA*, *BB* and *CC* for three calls which are identical in all respects except the times before expiration. The function *AA* represents the possible values for an option with, comparatively, the shortest time before expiration; while functions *BB* and *CC* are for options with longer times to expiration. This means that options with longer lives have higher time values than options with shorter lives. The curvature of the function indicates that although the values of in-the-money call options would be greater than those of out-of-the money options, the relationship is not linear. It may further be observed that the time value of an option is maximum when the price of the stock is at the exercise price. This excess, or time value, decreases when the price of the stock moves away from the exercise price in either direction.

Put Option

Figure 5.2 provides a graphical description of put option valuation. Like a call option, a put option also would have a minimum value equal to its intrinsic value which is the excess of exercise price over the stock price. With every rupee increase of share price, the minimum value of the option, if it is in-the-money, will decline by an equal amount. For example, assume the share price is Re 0 and the exercise price is Rs 50. The put option will have a minimum value equal to its intrinsic value of Rs 50 – Re 0 = Rs 50, equal to its exercise price. Now, if the stock price rises to Rs 20, the minimum value of the put decreases to Rs 50 – Rs 20 = Rs 30, and if the stock price is equal to the exercise price, the minimum value of the put will be Re 0. In the figure, the minimum-value line is obtained by joining the points indicating exercise price on each of the two axes. On the upper side, the put can have a value at most equal to the exercise price since the stock price cannot be negative. Therefore, the maximum value



function is shown as a horizontal line drawn at a height equal to the exercise price. The value of a put must be on or above the minimum value function, and on or below the maximum value function. As in case of call option, an in-the-money put option will have a higher value than an out-of-the-money put and the relationship is not a linear one. Also, the put with longer lives have greater values, as demonstrated through the functions *AA*, *BB* and *CC* which differ only in terms of the length of time before expiration.

CHARACTERISTICS OF OPTION VALUES

While the graphic approach for depicting values of options is useful in gaining an initial insight into the premia that the call and put options may command, we now give a more formal way of expressing the values of these derivatives. This is followed by the two more generally used models by which the values of the options may be determined.

We first derive an expression for the minimum value of a European call option. Then, it is shown that although an American call can be exercised at any time before the expiration date, it is not prudent to do so, but the same cannot be concluded for an American put option. This is followed by a discussion of 'put-call parity' which describes how the values of call and put are related and can be stated in terms of each other. This is discussed first for the European calls and puts and then for the American calls and puts.

In the valuation of calls and puts, it is usually assumed that the stock on which they are based pays no dividend during the currency of the option. However, if a dividend can be expected, then it would affect these values. The effect of dividends is discussed after the put-call parity relationship. This discussion is followed by a consideration of the various factors which affect the values of the call and put options and then of the two models which are commonly used for the valuation of options.

Minimum Value of a European Call

It can be shown that the value of a European call is the greater of zero and the difference between the stock price and the present value of the exercise price. For this, let us consider two portfolios specified

Portfolio P_1

1. Buy a call.
2. Buy bonds maturing at the expiration date of the call and which at that date will have a value equal to the exercise price.

If C is the current price of the call, E is the exercise price, r is the annual interest rate, and t is the time period elapsing between the point when the call is valued and the expiration date, then the amount needed to purchase bonds is Ee^{-rt}.

Portfolio P_2

Buy shares only.

Further, let S_0 be the current price of the shares purchased and S_1 be the stock price at the expiration date of the call, which may be less than, equal to, or more than the exercise price.

In Table 5.1, the key characteristics of both the portfolios are given.

Table 5.1

Characteristics of Portfolios

Portfolio	*Investment (Outflow)*	*Value at Expiration date*	
		If $S_1 > E$	*If $S_1 \leq E$*
P_1 : Buy Call	$-C$	$S_1 - E$	0
Buy Bonds	$-Ee^{-rt}$	E	E
	Total	S_1	E
P_2 : Buy Stock	$-S_0$	S_1	S_1

Thus, in case $S_1 > E$, the payoffs from both the portfolios are equal. However, in the event that $S_1 \leq E$, the portfolio P_1 would be as good as, or better than, the portfolio P_2. Obviously, therefore, the cost of portfolio P_1 should at least be as much as the cost of portfolio P_2. Therefore,

$$C + Ee^{-rt} \geq S_0 \quad \text{or} \quad C \geq S_0 - Ee^{-rt}$$

In words, the price of a call will be greater than, or equal to the difference between stock price and present value of the exercise price.

Early Exercise of an American Call

In contrast to a European call which can be exercised only on the due date, an American call may be exercised at any time before the expiration date. Notwithstanding this, it can be shown that it is never optimal to exercise an American call early, if the stock is non-dividend paying. To illustrate this, we consider an American call option on a non-dividend paying stock with an exercise date two months away when the stock price is Rs 60 and the exercise price is Rs 50. Since the option is well in-the-money, the investor might be inclined to exercise it and make profit. However, if the investor plans to hold the share beyond two months, it may not be the best strategy. It would be better to keep the call and exercise it when it is due and earn an interest on Rs 50 for two months. Since the stock does not pay any dividend, no income from it is sacrificed.

Another advantage of not exercising the call is the possibility that the stock price may go below Rs 40 during the next couple of months. At the same time, if the investor believes that the stock is currently overpriced, then, instead of exercising the option and making a profit by selling the stock, the investor would do well to sell the option to another investor who wants to hold onto the stock. Such investors would certainly exist because, otherwise, the price of the stock would not have been Rs 60. This activity would enable the investor to get a higher profit since the price at which the option can be sold will be greater than its intrinsic value of Rs 10. Consequently, it will never be more advantageous to exercise an American call before its exercise date.

Early Exercise of an American Put

In contrast to the fact that it would not be optimal to exercise an American call before the exercise date, it may be seen that it can be optimal to exercise an American put option on a non-dividend paying stock early. To illustrate this we may consider an extreme situation in which the exercise price is Rs 20 and the underlying stock is selling at a price which is nearly zero. An immediate exercise of the put option causes an immediate gain of Rs 20. If, however, the investor waits, the gain from exercising the put might be lowered (if the stock price recovers) and, in any case, it cannot exceed the present gain of Rs 20 since the stock prices cannot assume negative values. Further, a receipt of Rs 20 now is preferable to an equal amount receivable at some time in the future due to the time value of money.

In the same manner as a call option, a put option may be considered as a provision of insurance. A put option, held along with the stock, provides an insurance cover to the holder against any fall in stock price below a certain level. However, unlike the situation for a call option, it may be better for an investor to forego this insurance and exercise the put early so as to obtain the exercise price immediately. In general, a fall in the stock price, an increase in the riskfree rate of interest and decrease in the variability in the price of the underlying share make an early exercise more attractive. It may be shown that provided $r > 0$, it is always optimal to exercise an American put immediately when the stock price is sufficiently low. In case an early exercise is optimal, the value of the option will be $E - S$.

Since there exist circumstances when it is desirable to exercise an American put option early, it follows that an American put option is worth more than a comparable European put option.

Relationship Between European Call and Put Options: Put-Call Parity

A call and the underlying equity can be combined so that they have the same payoff as a put. Similarly, a put and the underlying stock can be combined to yield the same payoff as a call. This permits the put or call to be priced in terms of the other security. This relationship is the easiest to derive for European call and put options. For this, we consider two portfolios:

Portfolio P_1	One European call option Cash for an amount of $E e^{-rt}$
Portfolio P_2	One European put option One share of stock worth S_0

At the expiration of options, both the portfolios have the same values as shown in Table 5.2.

Since both the portfolios have identical values on expiration, they must have equal values at present as well. Accordingly, we have,

$$C + E e^{-rt} = P + S_0$$

Table 5.2

Determination of Terminal Values of Portfolios

Portfolio	*Cash Flow at t = 0*	$S_t > E$	$S_t \leq E$
P_1	C	$S_1 - E$	0
	$E\,e^{-rt}$	E	E
	Total	S_1	E
P_2	P	0	$E - S_1$
	S_0	S_1	S_1
	Total	S_1	E

From this, the value of a European put with a certain exercise price and expiration date can be deduced from the value of a European call with even price and date, and vice-versa.

Obviously, when the above equation does not hold, arbitrage opportunities would be present. Suppose, for example, that the current price of a stock is Rs 50, the exercise price is Rs 48, the riskfree continuously compounded rate of interest is 10% per annum. Suppose further that the price of a 3-month European call option is Rs 6 and the price of a 3-month European put option is Rs 4. Here,

Value of portfolio $P_1 = C + E\,e^{-rt} = 6 + 48\,e^{-(0.10 \times 3/12)} = 52.81$

Value of portfolio $P_2 = P + S_0 = 5 + 50 = 55$

Thus, portfolio P_2 is overpriced in comparison to portfolio P_1. In such a case, we may buy securities in portfolio P_1 and short the securities in P_2. This involves buying the call and shorting both the put and the stock. This would create a cash flow of – Rs 6 + Rs 4 + Rs 50 = Rs 48. Its investment at the riskfree interest rate would yield Rs 48 $e^{0.1 \times 0.25}$ = Rs 49.21 in the three months' period. At the conclusion of three months, if the stock price is greater than Rs 48, then the call will be exercised and if the stock price is smaller than that, then the put option will be exercised so that, in either case, the investor would end up buying the stock for Rs 48. The net profit, therefore, is Rs 49.21 – Rs 48 = Rs 1.21.

On the other hand, if the call price is Rs 6 and the put price is Rs 2 then,

Value of portfolio $P_1 = C + E\,e^{-rt} = 6 + 48\,e^{-(0.10 \times 0.25)} = 52.81$

Value of portfolio $P_2 = P + S_0 = 2 + 50 = 52$

In this case, portfolio P_1 is overpriced relative to portfolio P_2 and, therefore, an arbitrageur can short the securities in P_1 and buy securities in P_2, to book a profit. The strategy involves an initial outlay of Rs 50 + Rs 2 − Rs 6 = Rs 46. Financed at the riskfree rate, a repayment of 46 $e^{0.1 \times 0.25}$ = Rs 47.16 would be required to be made. Since both a call and a put are owned, either of these will be exercised. The short call and long put option position would lead to the stock being sold for Rs 48. The net profit would, therefore, be Rs 48 − Rs 47.16 = Re 0.84.

Thus, the principle of put-call parity states that the prices of call and put options on an asset are related and, given the value of one, the value of the other can be obtained. The relationship can be expressed as follows:

$$C + E e^{-rt} = P + S_0$$

Further, it may be observed that by re-arranging the terms in the above equation, we get $C - P = S_0 - E e^{-rt}$. Now, if the options are at-the-money so that $S_0 = E$, and if the stock pays no dividends, then we have

$$C - P = S_0(1 - e^{-rt})$$

or

$$\frac{C}{S_0} - \frac{P}{S_0} = 1 - e^{-rt}$$

On the RHS of the equation, e^{-rt} indicates the present value of Re 1. Accordingly, the expression $1 - e^{-rt}$ represents the difference between present and discounted value of rupee 1, which is nearly equal to the rate of interest. Hence, we may conclude that when the options are at-the-money and the underlying stock pays no dividends, relative call prices (C/S_0) would exceed relative put prices (P/S_0) by about the risk-free rate of interest.

Relationship Between American Call and Put Options

The put-call parity described above holds for European options only. We have already seen that for non-dividend paying stock, an American put option has a greater value than a European one. Accordingly, the value of an American put option is such that

$$P > C + E e^{-rt} - S_0$$

or,

$$C - P < S_0 - E e^{-rt}$$

Now, let us consider two portfolios:

Portfolio P_1 One European call option
An amount of cash equal to E

Portfolio P_2 One American put option
One share

Further, suppose that both options have the same exercise price and expiration date. Let the cash in portfolio P_1 be invested at the riskfree rate of interest. If the put option is not exercised early, the portfolio P_2 will be worth S_1 or E, whichever is higher, at the time of exercise. On the other hand, the portfolio P_1 would be worth S_1 or E, whichever is higher, plus $E e^{rt} - E$. Thus, portfolio P_1 would be worth more than portfolio P_2.

Now, suppose that the put option in portfolio P_2 is exercised early at a time t_1, it implies that portfolio P_2 is worth $E e^{r(t_1 - t)}$ at time t_1. However, even if the call option were worthless, portfolio P_1 would be worth $E e^{r}$ at time t_1. It follows, then, that portfolio P_1 is worth more than portfolio P_2 in all cases. Thus,

$$C + E > P + S_0$$

or $$C - P > S_0 - E$$

or $$S_0 - E < C - P < S_0 - E\, e^{-r(t_1 - t)}$$

Effect of Dividends

In our analysis so far, we have assumed that the options that we are dealing with, are options on a stock which is non-dividend paying. We may now consider the question of dividends. It the dividend (s) payable during the life of an option can be assessed, the option valuation can be suitably modified. Thus, if D be the present value of dividends (assumed to occur at the time of ex-dividend date) during the life of the option, then the lower bound on the call value and on the put value for a European option derived earlier can be adjusted for D as follows:

$$C > S_0 - D - E\, e^{-rt}, \text{ and}$$

$$P > D + E\, e^{-rt} - S_0.$$

Adding the present value of dividend(s), D, to the present value of he exercise price has the effect of reducing the value of a call and ncreasing the value of a put. Further, when the dividends are xpected, it cannot be said that an American call will not be exercised early. At times, it may be best to exercise an American call immediately prior to an ex-dividend date because the dividend may cause the stock price to jump, making the option less attractive. Of course, it is not optimal to exercise a call at other times.

It may be shown for put-call parity (of a European option) that

$$C + D + E e^{-rt} = P + S_0$$

Similarly, the inequality mentioned for American option would be modified as follows:

$$S_0 - D - E < C - P < S_0 - E e^{-rt}$$

Factors Affecting Option Prices

There are several factors affecting the price of a stock option. They include:

1. Stock price.
2. Exercise price.
3. Time to maturity.
4. Dividends, if any, expected during the life of the option.
5. Riskfree interest rate.
6. Volatility in the stock price.

We now consider these in turn.

Stock Price When a call option is exercised, the payoff resulting therefrom equals the excess of stock price over the exercise price. Thus, a call option will be more valuable when stock price increases and less valuable when it decreases. On the other hand, for a put option, the payoff is the difference between exercise price and the stock price. As such, the higher the stock price, for a given exercise price, the lower will be the value of the option.

Exercise Price A call option with a higher exercise price cannot be expected to be valued higher than another call with the same parameters but with a lower exercise price. To understand this feature, consider calls on a stock with the same exercise date, but with varying exercise prices. For example, suppose two calls on a stock with identical exercise dates have exercise prices of, Rs 180 and Rs 190 respectively. The holder of the former call can buy the underlying security at Rs 180, and can be in the same position as the holder of the other call who could buy the same security at Rs 190, *plus* the cash left over. Obviously, therefore, the call with a higher exercise price cannot be valued higher.

Length of Time to Expiration The effect of time to expiration on the option price depends on whether the option is of the American or of the European style. The American call and put options become more valuable as the time to expiration increases. If we consider two calls on the same stock with identical exercise prices but with different exercise dates, it can be easily visualized that the one with the longer life (i.e., one with a latter expiration date) would offer the investor all the exercise opportunities as those of the one with a shorter life, and some additional opportunities as well. It may be, therefore, reasonably expected that of the two comparable calls, the one with a longer life will not be valued lower than the one with a shorter life.

However, European put and call options do not necessarily become more valuable as the time to expiration increases. This is because the owner of the option with longer life does not enjoy all opportunities open to the owner of the one with a shorter life since the option can be exercised only at maturity. For instance, if an investor has two call options—one with an expiration date in one month and the other with expiration date in two months—and a handsome dividend is expected in a month-and-a-half's time, then the price of the underlying stock is likely to decline by the second month. Accordingly, it is probable that the option with smaller time to expiration has a value greater than the value of the other option.

Dividend Dividends on stock have the effect of reducing the stock price on ex-dividend date. Therefore, this affects the value of call options adversely and of put options favourably. The effects on option prices are related to the amounts of dividends expected.

Interest Rate The impact of a riskfree interest rate on option prices is rather indirect. An increase in the riskfree rate of interest leads to an increase in expected growth rate in the stock option prices, on the one hand, and a decrease in the present value of any cash flows received by the holder of an option, on the other. Both these have an adverse impact on the value of the put options. For the call options, the first of the two effects has a larger impact than the second one, with the result that a call option price would increase with an increase in the riskfree interest rate.

Volatility A major factor affecting the price of options is volatility, which is the degree to which price of a stock or an index tends to fluctuate over a certain period of time. As volatility increases, the chance that the stock would do very good or very bad increases.

These two outcomes tend to have an offsetting effect on the holder of the stock. But the situation is different for the owner of a call or put option. For instance, the owner of the call benefits from the price increase but his downward risk is limited since the most he can lose is the option premium. Similarly, the owner of a put option profits from a decrease in the stock price and his risk in case of adverse, upward price movement is limited. Thus, the values of both calls and puts exhibit increases with increases in the degree of volatility.

MODELS OF VALUATION OF OPTIONS

There are a number of models available for valuation of options. Two of the more important ones are: binomial option pricing model and Black and Scholes option pricing model. Both the models are in respect of the European call options. The difference in the two models of option valuation stems basically from the assumptions made about how share prices change over time. While the binomial model assumes that percentage change in share price follows a *binomial distribution*, the Black and Scholes model is based on the assumption that it follows a *log normal distribution*.

It was shown earlier that it never pays to exercise an American call before its expiration if the stock involved would not pay dividend before the expiration date or if the call is dividend protected. Thus, an American call, which satisfies this condition, will be just like a European call and can be evaluated in the same manner.

The Binomial Model

The binomial model of option valuation uses a numerical approach. The model is based on the assumption that if a share price is observed at the start and end of a period of time, it will take one of the two values at the end of that period, i.e., the model assumes that the share price would move up or down to a predetermined level.

For a step-by-step development of the model, let us consider the valuation of a call one period prior to expiration. Now, suppose that a stock is currently selling at Rs 60, and that after one period it would be selling either for Rs 40 or for Rs 80. If the rate of interest, for borrowing and lending both, is assumed to be 25% for the one period, we may determine the value of the call with an exercise price of Rs 60 as follows:

Consider a portfolio consisting of writing two calls, buying one share of the stock, and borrowing Rs 32. In both the events, of the share price falling to Rs 40 or rising to Rs 80, the cash flows at the end of the period, $t = 1$, will be zero as shown in Table 5.3. It may be noted that if the stock price at $t = 1$ is Rs 40, the calls will not be exercised, while if it is at Rs 80, then a loss of Rs 40 [= (80 – 60) × 2] would be incurred on the calls. In either case, the loan of Rs 32 will be repaid together with an interest of Rs 8 (= 25% of the amount borrowed). This implies that in either case, the investor receives nothing and, therefore, the value of the calls would be such that the portfolio has a value of zero. Accordingly, we set $2C - 60 + 32 = 0$ to get $C =$ Rs 14, where C is the price of the call.

Table 5.3

Valuation of Call

Portfolio	*Flows at the beginning, $t = 0$*	*Flows at $t = 1$*	
		$S_1 = 40$	*$S_1 = 80$*
Write 2 Calls	+ 2C	0	– 40
Buy a Share	– 60	+ 40	+ 80
Borrow	+ 32	– 40	– 40
Total	$2C - 28$	0	0

It may be shown that if the call is selling at price higher or lower than Rs 14, then it is possible to make a profit. For instance, suppose that the call is underpriced and is selling for Rs 10. It is prudent, in such a case, to buy the call, shorting the stock and lending. As shown earlier, cash flow at $t = 1$ will be zero in either case but at $t = 0$, the flows are:

	Flow
Buy two calls	– 20
Short one share	+ 60
Lend	– 32
Total	+ 8

It can similarly be shown that if the call is valued at a price greater than Rs 14, then profit can be earned by creating a portfolio consisting of writing two calls, buying a share and borrowing Rs 32. To conclude, then, the call cannot sell for higher or lower than the value derived earlier. Now we can make some generalizations.

Hedge Ratio In the above example, we constructed the portfolio in such a manner that payoffs from calls and stock were the same, irrespective of the price of stock prevailing at $t = 1$. Further, resorting to lending or borrowing enabled us to have a zero return at $t = 1$. In our illustration, we used two calls and one share of stock to yield a flow of Rs 40 irrespective of whether the price went up to Rs 80 or down to Rs 40. In general terms, the number of shares of stock per call, which makes the payoff from the combination independent of the price of share is known as *hedge ratio*. In our example, the hedge ratio is 1/2 (one share of stock for two calls).

Now, let

S_0 = the stock price at $t = 0$.

S_1 = the stock price at $t = 1$.

E = exercise price of the call option.

C = call price.

u = 1 + percentage change in stock price from $t = 0$ to $t = 1$, if the stock price increases. In such a case, $S_1 = uS_0$.

d = 1 + percentage change in stock price from $t = 0$ to $t = 1$, if the stock price decreases. For this case, $S_1 = dS_0$.

α = number of shares of stock purchased per share of the call (for example, if the number of shares purchased = 15, and a call involves 100 shares, than $\alpha = 15/100 = 0.15$)

C_u = value of call if $S_1 > S_0$, $C_u = \max(uS_0 - E, 0)$

C_d = value of call if $S_1 < S_0$, $C_d = \max(dS_0 - E, 0)$

Consider the situation given in Table 5.4. To make the portfolio to be a hedged one, the flows at $t = 1$ should be made independent of the stock price. In other words,

$$- C_d + \alpha dS_0 = - C_u + \alpha uS_0$$

or $$\alpha uS_0 - \alpha dS_0 = C_u - C_d$$

Thus, $$\alpha = \frac{C_u - C_d}{S_0 (u - d)}$$

Table 5.4

Portfolio Flows

Portfolio	Flows at $t = 0$	Flows at $t = 1$	
		$S_1 = dS_0$	$S_1 = uS_0$
Write a Call	C	$-C_d$	$-C_u$
Buy α shares of Stock	$-\alpha S_0$	αdS_0	αuS_0

For our example, $C_d = 0$, $C_u = 20$, $S_0 = 60$, $u = 80/60 = 4/3$ and $d = 40/60 = 2/3$. Accordingly,

$$\alpha = \frac{20-0}{60\left[\frac{4}{3}-\frac{2}{3}\right]} = \frac{20}{60 \times \frac{2}{3}} = \frac{1}{2}$$

Thus, in order to have the combination of calls and stock yield the same payoff, regardless of the value of stock at $t = 1$, we should buy one-half as many shares of stock as the number of calls that are written. Obviously, α represents the hedge ratio.

Using the hedge ratio of α implies that the flows at $t = 1$ are equal to $-C_d + \alpha dS_0$, or $-C_u + \alpha uS_0$. To make the value of the portfolio zero at $t = 1$, we should borrow such an amount so that the flows become $C_d - \alpha dS_0$ (or $C_u - \alpha uS_0$). If we let i equal to one *plus* rate of interest for one period of time, the amount needed to be borrowed will be $(C_d - \alpha dS_0)/i$. With the cash flows of C from writing a call, $-\alpha S_0$ from buying α stock and $(-C_d + \alpha dS_0)/i$ from borrowing, we can set their sum equal to zero (because the value of portfolio at $t = 1$ is equal to zero), to get

$$C - \alpha S_0 - \frac{C_d - \alpha dS_0}{i} = 0$$

or

$$C = \frac{\alpha i S_0 + C_d - \alpha dS_0}{i}$$

Substituting the value of α obtained above into this equation and simplifying, we get

$$C = \frac{C_u \frac{(i-d)}{(u-d)} + C_d \frac{(u-i)}{(u-d)}}{i}$$

Setting $P = (i-d)/(u-d)$, we get

$$C = \frac{C_u P + C_d(1-P)}{i}$$

Alternatively, we may derive the value of an option by taking the present value of the various possible expiration values of the option, multiplied by the respective probabilities for those values to occur. It can be represented in the following manner.

If C be the price of a call, and the value of the stock after an incremental period of time is either C_u with a probability P or C_d with a probability of $1 - P$, the expected return after one time period would be $C_u(P) + C_d(1 - P)$. If i is set equal to one *plus* riskfree rate over this time limit, then the value of the call would be:

$$C = \frac{1}{i}\,[C_u\,P + C_d(1 - P)]$$

Here $P = (i - d)/(u - d)$, where d and u are two possible rates of return on the share after an incremental period of time.

In fact, looking at the formulations for the calculation of P, it is amply clear that P and $1 - P$ are not probabilities. But their use as probabilities to derive the expected value in a situation where stock price is assumed to take only one of the two values gives the prefix 'binomial' to the valuation model.

Extension to Multiple Periods The valuation of a call option can be extended to multiple time periods. To begin with, we may consider the possibilities where an option has two periods to go for maturity. They are shown in Fig. 5.3. In this case, C_{u^2} is the value at expiration if there are two up movements in the stock price. It equals max $(u^2 S_0 - E, 0)$. C_{ud} is the value of option at expiration if there is one upward and one down movement in the stock price. It is equal to max $(ud\,S_0 - E, 0)$. Similarly, C_{d^2} is the value at expiration if two down movements are registered in the price of the share. Therefore, the value of the option at $t = 1$ can be obtained as follows:

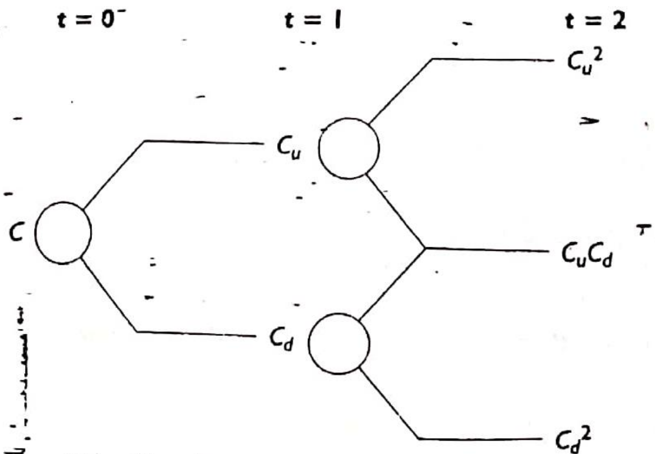


Fig. 5.3 *Tree Diagram showing Call Option Values*

if the share price is uS_0

$$C_u = \frac{PC_{u^2} + (1-P)\,C_{ud}}{i}$$

if the share price is dS_0

$$C_d = \frac{PC_{ud} + (1-P)\,C_{d^2}}{i}$$

Knowing the values at $t = 1$, we may proceed to determine the value of the option at $t = 0$ by assuming that there is only one time period to go. Accordingly,

$$C = \frac{P\dfrac{PC_{u^2} + (1-P)\,C_{ud}}{i} + (1-P)\dfrac{PC_{ud} + (1-P)C_{d^2}}{i}}{i}$$

On simplification, we get

$$C = \frac{P^2 C_{u^2} + 2P(1-P)C_{ud} + (1-P)^2\, C_{d^2}}{i^2}$$

The same approach may be extended to three or more periods. For a three period case, the value of call option, C, can be determined as follows:

$$C = \frac{P^3 C_{u^3} + 3P^2(1-P)C_{u^2 d} + 3P(1-P)^2\, C_{ud^2} + (1-P)^3\, C_{d^3}}{i^3}$$

We may generalize the results to obtain an expression for the valuation of a call n periods before maturity, as given below:

$$C = \frac{\sum_{j=0}^{n} \dfrac{n!}{j!(n-j)!} P^j\,(1-P)^{n-j} \max[0, u^j d^{n-j}\, S_0 - E]}{i^n}$$

Notice the numerator, the first part of which is simply the binomial expansion

$$(a+b)^n = C_0^n\, a^{n-0}\, b^0 + C_1^n\, a^{n-1}\, b^1 + C_2^n\, a^{n-2}\, b^2 + \cdots + C_n^n\, a^{n-n}\, b^n$$

$$= \sum_{j=0}^{n} C_j^n\, a^{n-j}\, b^j$$

while the other part gives the conditional value of the call option at each step, j.

The above expression may be simplified by considering the fact that there would be a certain minimum number of upward movements necessary for it to pay to exercise the option at the date of maturity. If we represent this number by k, then it is clear that for sequences with less than k upward movements, the call will not be exercised and it will have a value of zero at expiration.

Thus, it is evident that the summation should begin only at K. When this is done, max $(0;\ u^j d^{n-j} S_0 - E)$ should be replaced by $u^j d^{n-j} S_0 - E$. Now, the expression for valuation can be reworked and simplified to eventually lead to the following:

$$C = S_0\, B(k, n, P') - E\, i^{-n}\, B(k, n, P)$$

wherein $P = (i - d)/(u - d)$; $1 - P = (u - i)/(u - d)$, $P' = Pu/i$; and $B(k, n, P')$ is the probability of the number of up movements (successes) in the share price to be up at least equal to k out of n movements, where the probability of an up movement is P'.

From the preceding analysis it follows that the price of a call option is influenced by a number of factors including the current share price, the exercise price, the size of the up movement, the size of the down movement, the riskfree rate of return and the number of periods remaining until expiration.

The binomial option pricing model has the merit that because of the step-by-step approach, it can accommodate specific events like dividends during the life span of the option. But, while a small number of intervals make the option price determination easier, the computations tend to become tedious when a larger number of intervals is considered. No wonder, then, computers are needed for making calculations when the number of time periods involved are large. In fact, by letting the length of the period between up or down movements to become very small, and thereby making the number of periods very large, the binomial formula can be utilized to derive other valuation formulations that allow a continuous change in price. As the number of time intervals becomes higher and higher, the binomial distribution converges to a normal distribution. The Black and Scholes model discussed in the following pages is based on this concept.

Example 5.1

The current price of a share is Rs 50, and it is believed that at the end of one month the price will be either Rs 55 or Rs 45. What will a European call option with an exercise price of Rs 53 on this share be valued at, if the riskfree rate of interest is 15% per annum? Also calculate the hedge ratio.

From the given data, we may define various inputs needed for valuing an option as follows:

C_u (the value of call option if $S_1 > S_0$) = $S_1 - E = 55 - 53$ = Rs 2

C_d (the value of call option if $S_1 < S_0$) = max ($S_1 - E$, 0)

= max (45 – 50, 0) = 0

$u = S_1/S_0$ when the stock price increases (i.e., $S_1 > S_0$) = 55/50 = 1.1

$d = S_1/S_0$ when the stock price decreases (i.e., $S_1 < S_0$) = 45/50 = 0.9

i = 1 *plus* riskfree rate of return applicable for the time interval = 1 + (0.15/12) = 1.0125

(since the annual rate is given to be 15%)

Accordingly, the value of a call would be:

$$C = \frac{C_u \dfrac{(i-d)}{(u-d)} + C_d \dfrac{(u-i)}{(u-d)}}{i}$$

$$C = \frac{2\dfrac{(1.0125 - 0.9000)}{(1.1000 - 0.9000)} + 0\dfrac{(1.1000 - 1.0125)}{(1.1000 - 0.9000)}}{1.0125}$$

$$= \frac{0.2250}{0.2025} = \text{Rs } 1.11$$

Further, we know that hedge ratio,

$$\alpha = \frac{C_u - C_d}{S_0(u-d)}$$

Substituting the known values in this equation,

$$\alpha = \frac{2-0}{50(1.10 - 0.90)} = 0.2$$

Thus, the price of the call option = Rs 1.11 and hedge ratio = 0.2.

We may illustrate the binomial valuation model using a multi-period case with an example. It is kept simple in that discounting is not resorted to.

Example 5.2

Suppose that an index is at 3000 and it will change with equal probability by either 10 or 8 in each time interval. Now, consider an American put option on this index with exercise price of 3010, which would expire in three periods. The problem is to determine the fair value of the option at each step.

For this, we first determine the various index possibilities by means of a tree. Once the tree depicting various possibilities is drawn up, we may determine the possible values of the option at expiry. This would enable us to calculate fair values for the option at any point on the index value tree. This is done by comparing the value of holding and the value of immediate exercise at each node and then selecting the optimum value. The process is then repeated at each node towards the origin, including the base of the tree. This enables us to determine the fair price of the option at any point and the optimal point where it may be exercised, as it is an American option.

For the given data, the index tree showing the movement of index over time is shown in Fig. 5.4. From the figure, it is clear that the index values after the three-period interval would be 3030 (all up movements), 3012 (two up and one down movements), 2994 (one up and two down movements) and 2976 (no up movements).

At $t = 3$, the put will eventually have the following values:

1. For index values 3030 and 3012; $P = 0$ (being a put option it will not be exercised when $S_1 > E$).
2. For index value 2994; $P = 3010 - 2994 = 16$.
3. For an index of 2976; $P = 3010 - 2976 = 34$.

At $t = 2$, one time step before the expiry, the option would have the following values:

1. If the index is at 3020, the next step will result in the put option of 3010 expiring unexercised (possible indices being 3030 and 3012). At 3020, the put value is zero, since the index is higher than the exercise value. Therefore, at this point, the option is worthless.

2. In the event the index is at 3002, the option has even chances of either becoming worthless or worth 16 on expiry. Thus, the expected value is $0.5 \times 0 + 0.5 \times 16 = 8$. Immediate exercise of the option will also yield $3010 - 3002 = 8$. Thus, at this point, the value of the option $= 8$.

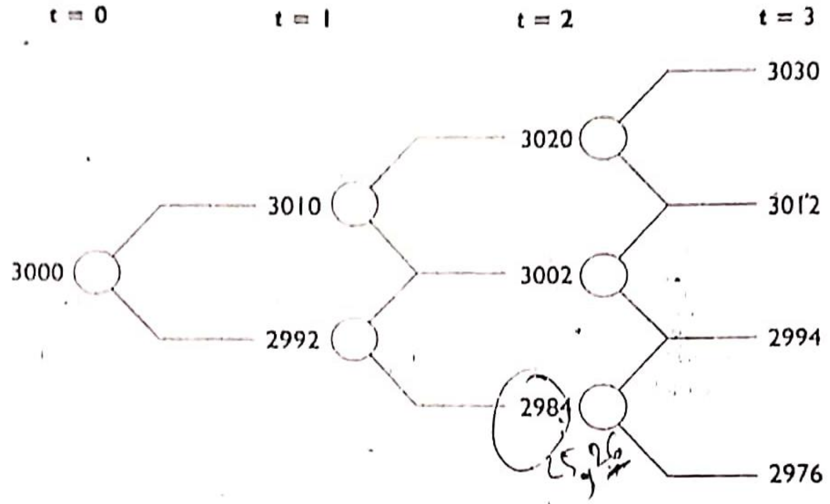


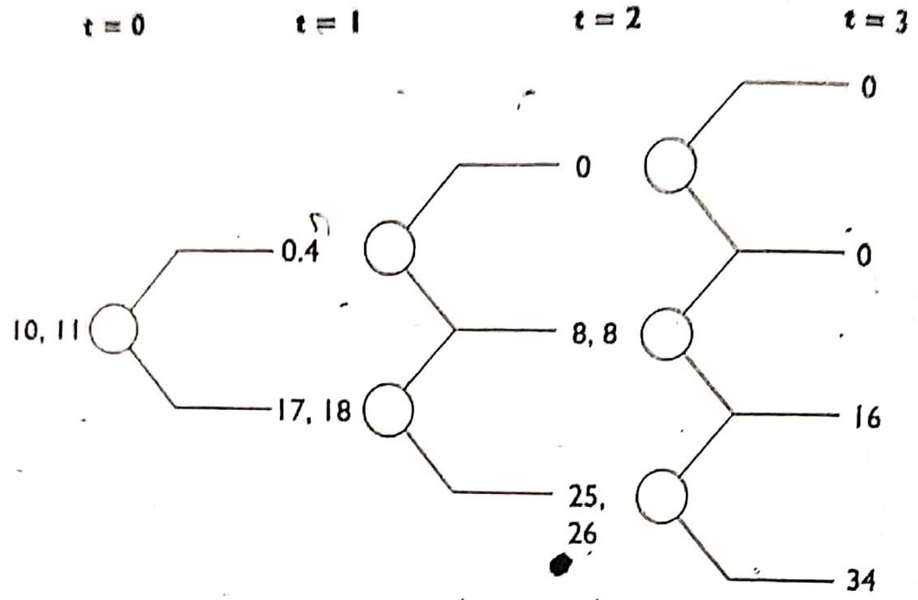
Fig. 5.4 *Tree Diagram showing Index Movement*

3. When the index is at 2984, the option has an expected value of $0.5 \times 16 + 0.5 \times 34 = 25$. An immediate exercise of this option, on the other hand, will yield $3010 - 2984 = 26$. As this is preferable, the option should be exercised and this is taken as the correct option value.

Continuing in the same manner, at $t = 1$, when the index is at 3010, the option, if exercised immediately, will yield nothing, while its expected value would be equal to $0.5 \times 0 + 0.5 \times 8 = 4$. The value of the option can, therefore, be taken to be 4. Similarly, in the event of the index being at 2992, the expected value equals $0.5 \times 8 + 0.5 \times 26 = 17$, and its immediate exercise results in a value of $3010 - 2992 = 18$. Thus, the correct value of the option is 18.

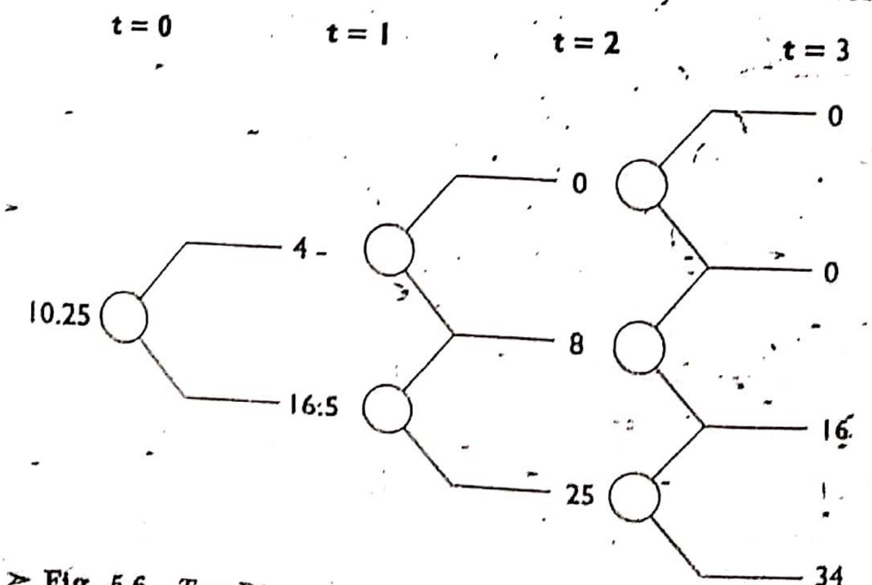
To complete the process, the value of the put at the base of the tree is $0.5 \times 4 + 0.5 \times 18 = 11$, while its prompt exercise would give $3010 - 3000 = 10$. Consequently, the appropriate value of the option is 11 at $t = 0$.

The values of the option at various points are contained in the tree diagram given in Fig. 5.5. At each node, from $t = 0$ through $t = 2$, two values are shown: the one resulting from immediate exercise and the other depicting the expected value. In each case, the higher of the two values involved is taken and used for making calculations. Note that all calculations are made in a backward manner.



➢ Fig. 5.5 *Tree Diagram showing Put Option Values*

If the option in the above example would have been a European one whose early exercise is not possible, the call valuation could be done more easily. For the example under consideration, the value would be 10.25, as shown in the tree diagram given in Fig. 5.6. The European put is thus cheaper 0.75 than the American put—the differential being the extra cost of exercise facility in the latter case.



➢ Fig. 5.6 *Tree Diagram showing Values of European Style Option*

Subject: Financial Derivatives (4539292)

MBA SEM 03
Module 04

BLACK-SCHOLES OPTIONS PRICING MODEL

The Black and Scholes Model

In 1973, Fisher Black and Myron Scholes propounded a model for valuation of options. According to the Black and Scholes formulation, the value of a call option is calculated as follows:

$$C = S_0\, N(d_1) - E\, e^{-rt}\, N(d_2)$$

where
$$d_1 = \frac{\ln(S_0/E) + (r + 0.5\sigma^2)t}{\sigma\sqrt{t}}$$

$$d_2 = \frac{\ln(S_0/E) + (r - 0.5\sigma^2)t}{\sigma\sqrt{t}}$$

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

C = current value of the option

r = continuously compounded riskfree rate of interest

S_0 = current price of the stock

E = exercise price of the option

t = time remaining before the expiration date (expressed as a fraction of a year)

s = standard deviation of the continuously compounded annual rate of return

$\ln(S_0/E)$ = natural logarithm of (S_0/E)

$N(d)$ = value of the cumulative normal distribution evaluated at d

Assumptions Underlying Black and Scholes Model The Black and Scholes valuation model is based on certain assumptions. These are:

1. The option being valued is a European style option, with no possibility of an early exercise. Comparable American call options are more valuable because they provide greater flexibility of exercise. However, this is not a major pricing consideration since only a few calls are exercised before the last few days of their life. This is simple to understand because an option holder who exercises the option early virtually throws away the time value remaining on the call. Thus, if one holds a call option at Rs 58, one can always buy shares at this rate by virtue of the call. Now, if the share is currently selling at, say, Rs 70 one may be tempted to exercise the option and make a profit of Rs 1200 (on 100 shares). But what is important to understand is that the better alternative in such a case would be to sell it in the market where it will fetch a minimum price of Rs 1200, its intrinsic

value. In last few days before the expiry of the option, the time value is negligible. Thus, the valuation is nearly same for an American option as well.

2. There are no transaction (dealing) costs and there are no taxes. This of course, is not true. There are commissions and other costs to be paid by the investors which may be substantial at times and therefore, affect the true cost of an option position. Since such costs and the tax impact vary among investors, it is likely to result in a different cost of an option to different investors.

3. The risk-free interest rate is known and constant over the life of the option.

4. The market is an efficient one. This implies that as a rule, the people cannot predict the direction of the market or any individual stock. Market efficiency is a central paradigm in modern finance theory. Of course, doubts are always expressed whether the assumption is indeed valid. Though, efficient market theory may not provide a very good explanation of investor behaviour, it surely gives a better explanation than others.

5. The underlying security pays no dividends during the life of the option. Thus, the model would yield the same price for options with identical inputs on two securities which are same in all respects, except that they have different dividend yields. It can be easily visualised that the higher the yield of dividend, the lower the call premium and thus, the market prices of the calls are not likely to be the same.

However, the fact that different securities do pay dividends does not render the model useless. Once the option value is determined using the model, the value is adjusted for the dividend expected on the security. This is explained later in the chapter.

6. The volatility of the underlying instrument (may be the equity share or the index) is known and is constant over the life of the option.

7. The distribution of the possible share prices (or index levels) at the end of a period of time is log normal or, in other words, a share's continuously compounded rate of return follows a normal distribution. Essentially, this means that the share (or index) in question has the same likelihood to double in value as is it to halve,

with the added implication that the share prices (or indices) cannot become negative.

An Intuitive Idea of the Valuation Model To have a basic idea about the Black and Scholes model, let us reconsider the formula $C = S_0\, N(d_1) - Ee^{-rt}\, N(d_2)$ and sub-divide it into two components as $S_0\, N(d_1)$ and $Ee^{-rt}\, N(d_2)$. In the first component, S_0 is the current price of the stock which, in terms of the theory of finance, is the discounted value of the expected price at any point in time in the future, while $N(d_1)$ is the probability that, at expiration, the stock price shall exceed the option exercise price. Similarly, contents in the second component of the equation may be viewed as the present value of having to pay the exercise price on the expiration day. Thus, the value of a call option is equal to the difference between the expected benefit from acquiring the stock now and paying the exercise price on expiration day.

Using the Black and Scholes Formula An examination of the formula reveals that the inputs required to value an option are: current price of the stock (S_0), exercise price of option (E), time remaining before expiration of the option (t), riskfree rate of interest (r), standard deviation of the continuously compounded annual rate of return (σ) on the stock/index and a normal probability table. The first three of these are easily observable while an idea about the riskfree rate of interest may be had by taking the rate of return on a government security that has a maturity date closest to the expiration date of the call.

However, there is some problem with regard to the standard deviation, which is the measure of volatility. As a first step, let us see how is the value of the standard deviation of the continuously compounded annual rate of return may be calculated using historical data on stock returns. The calculation of standard deviation involves the following steps:

1. Calculate *price relative* for each week using one year, or a fraction of a year's, historical weekly data. The price relative for a week is the ratio of the price at the weekend plus dividends, if any, to the price at the beginning of the week.

2. Find natural logarithms of each of the price relatives. This is the continuously compounded rate of return per week.

3. Calculate standard deviation of the series of continuously compounded rate of return as follows:

(a) Calculate the mean rate of return,

$$\bar{X} = \frac{\Sigma X}{n}$$

(b) Find the total of squared deviations of rates of return from the mean rate of return,

$$\Sigma(X - \bar{X})^2$$

(c) Use the following rule:

$$\sigma = \sqrt{\frac{\Sigma(X - \bar{X})^2}{n}}$$

Alternatively,

$$\sigma = \sqrt{\frac{\Sigma X^2}{n} - \bar{X}^2}$$

4. Convert the continuously compounded weekly standard deviation to a yearly standard deviation by multiplying it by the square root of 52.

Similar calculations can be done by using the data on daily prices. In that event, the continuously compounded daily standard deviation can be converted into the required standard deviation by multiplying by the square root of the number of trading days in the year. Also, if monthly data are used, then the required value is obtained by multiplying the monthly (standard deviation) value by square root of 12.

To understand the calculation of standard deviation, let us consider the hypothetical closing prices of a share over the last 15 weeks as given in the Table 5.5 Using the values in the second column, price relatives (*PR*) are obtained by dividing the closing price of a given week by the closing price of the preceding week. Accordingly, the first price relative is 42.50/40.00 = 1.0625, the second one is 41.70/42.50 = 0.9812, and so on. The fourth column in the table contains the natural log values of the price relatives. This represents the series of continuously compounded weekly rates of return. The mean and standard deviation of this series are calculated next, which work out to be 0.0103 and 0.0406 respectively.

$$\text{Mean} = \frac{0.1441}{14} = 0.0103$$

Standard deviation,

$$\sigma_w = \sqrt{\frac{0.02454205}{14} - (0.0103)^2} = 0.0406$$

The annual volatility can be obtained by converting the weekly standard deviation value into a yearly one by multiplying by $\sqrt{52}$. Accordingly,

$$\text{Annualized volatility} = \text{Weekly volatility} \times \sqrt{52}$$

$$= 0.0406 \times \sqrt{52} = 0.2928$$

Table 5.5

Calculation of Standard Deviation

Week	*Closing Price*	*Price Relative (PR)*	*ln PR = X*	X^2
1	40.00			
2	42.50	1.0625	0.0606	0.00367236
3	41.70	0.9812	– 0.0190	0.00036100
4	42.20	1.0120	0.0119	0.00014161
5	43.50	1.0308	0.0303	0.00091809
6	48.70	1.1195	0.1129	0.01274641
7	45.30	0.9302	– 0.0724	0.00524176
8	44.90	0.9912	– 0.0088	0.00007744
9	46.20	1.0290	0.0286	0.00081796
10	46.20	1.0000	0.0000	0.00000000
11	45.80	0.9913	– 0.0087	0.00007569
12	45.60	0.9956	– 0.0044	0.00001936
13	45.70	1.0022	0.0022	0.00000484
14	45.30	0.9912	– 0.0088	0.00007744
15	46.20	1.0199	0.0197	0.00038809
		Total	0.1441	0.02454205

The value of annualized volatility as derived above — termed the standard deviation of the distribution of continuously compounded annual rate of return, σ — is used in computing the value of a call option on a scrip.

Strictly, the Black and Scholes model requires the usage of σ as it is likely to be over the life span of the option. However, the model is derived under the assumption that rates of return are identically distributed over time. If this assumption were indeed to hold, then satisfactory estimates of standard deviation can be made from the historical data. The volatility measured on the basis of historical data is termed as *historical volatility*.

The historical volatility, together with the current market analysis and perception of the market serves as the basis of making estimate of the future volatility. The historical volatility measured on the basis of recent past data is generally taken as a reasonable estimate of the *projected volatility*.

Calculation of Call Option Value

The calculation of call option value using Black and Scholes model is demonstrated below.

Example 5.3

Consider the following information with regard to a call option on the stock of *ABC* company.

Current price of the share, S_0 = Rs 120

Exercise price of the option, E = Rs 115

Time period to expiration = 3 months. Thus, $t = 0.25$ years

Standard deviation of the distribution of continuously compounded rates of return, $\sigma = 0.6$

Continuously compounded riskfree interest rate, $r = 0.10$

With these inputs, the value of the call using Black and Scholes formula can be calculated as follows:

We first obtain the values of d_1 and d_2 as shown below:

$$d_1 = \frac{\ln(120/115) + (0.10 + 0.5 \times 0.6^2)(0.25)}{0.6\sqrt{0.25}} = 0.37$$

$$d_2 = \frac{\ln(120/115) + (0.10 - 0.5 \times 0.6^2)(0.25)}{0.6\sqrt{0.25}} = 0.07$$

From the table of the area under a normal curve, Table A2, we observe that for $z = 0.37$ ($= d_1$), the area = 0.1443 and for $z(= d_2) =$ 0.07, the area = 0.0279. These values give the areas between mean and the specified values of d_1 and d_2. Here we need the total areas under the normal curve to the left of d_1 and d_2, which are respectively 0.5 + 0.1443 = 0.6443 and 0.5 + 0.0279 = 0.5279. Thus,

$$N(d_1) = N(0.37) = 0.6443,$$
$$N(d_2) = N(0.07) = 0.5279$$

The value of the call is

$$C = 120 \times (0.6443) - \frac{115}{e^{0.10(0.25)}} (0.5279) = \text{Rs } 18.11$$

The use of the Black and Scholes formula has given the value of the call on *ABC* to be equal to Rs 18.11 for the data given in the example. Let us suppose that this call is selling at Rs 16.50. If the formula does give correct value of the call, then the call is undervalued in the market. In such an event, one can take advantage by purchasing the call. As an alternative, the investor can protect himself against unfavourable price changes by buying the call and selling the stock short.

Calculation of Put Option Value

Using the put-call parity, we can determine the put option value on *ABC* as follows:

$$P = C + E e^{-rt} - S_0$$
$$= 18.11 + 115\ e^{-(0.10)(0.25)} - 120 = \text{Rs } 10.27$$

Thus, to obtain the put option value, we first calculate a theoretical call option value using the Black and Scholes model and use the result as an input in the put-call parity model. Obviously, the value so derived is the put option that would exist without arbitrage opportunities.

In fact, it is not necessary to calculate the call option value before the put option value may be derived. The Black and Scholes model can be combined with the put-call parity model to directly obtain the put option value. This is given below:

$$P = Ee^{-rt} N(-d_2) - S_0 N(-d_1)$$

with all variables defined as earlier.

To consider again the Example 5.3, we have, $E =$ Rs 115, $r = 0.10$, $t = 0.25$, $S_0 =$ Rs 120, $d_1 = 0.37$ and $d_2 = 0.07$.

Accordingly, $N(-d_1) = N(-0.37) = 0.3557$ and

$N(-d_2) = N(-0.07) = 0.4721$

Now, $P = 115 \times e^{-0.10 \times 0.25} \times 0.4721 - 120 \times 0.3557$

$= 52.95 - 42.68 = \text{Rs } 10.27$

This value is identical to the one obtained earlier.

Recall that a call option with stock price exceeding the exercise price is an in-the-money option. With $S_0 =$ Rs 120 and $E =$ Rs 115, the intrinsic value of call is Rs 120 – Rs 115 = Rs 5. The time value of the option equals Rs 18.11 – Rs 5 = Rs 13.11. On the other hand, with S_0 = Rs 120 and E = Rs 115, a put option is out-of-the-money. Therefore, its intrinsic value is nil and the value of Rs 10.27 represents only the time value.

It may be noted that if the call and the put options involve a contract of 100 shares, then the buyer of a call option in the above case will be required to pay a sum of Rs 1,811, while a put option buyer will pay Rs 1,027 for one option. The values of C and P are essentially for a single share.

Sensitivity Analysis We have already discussed various factors affecting the values of options. Now, we examine the effects of changes in various parameters determining the option values in the context of the Black and Scholes model.

The begin with, consider the information given in Example 5.3. Let us term this information as the basic data. Then, basic data is:

Stock price, S_0 = Rs 120

Exercise price, E = Rs 115

Length of time before expiration = 3 months

Thus, $t = 0.25$ years

Standard deviation of the distribution of continuously compounded rate of return, $\sigma = 0.6$

Continuously compounded riskfree rate of interest, $r = 0.10$

From this data, we have,

Value of the call option = Rs 18.11

Value of the put option = Rs 10.27

To trace the effects of changes in different parameters on the call and put option values, the various parameter values in the basic data are changed and the call and put option premia are recalculated. It may be noted that all the changes in the parameter values are to be considered independently so that for a particular new parameter value all other values would be the same as in the basic data. The results for certain selected values are given in Table 5.6. The following points may be noted:

1. Other things being equal, an increase in the stock price results in an increase in the value of a call option because it becomes deeper in-the-money and, hence, its intrinsic value increases. On the other hand, the put option value registers a decline.

When the stock price becomes very large, a call option becomes liable to be certainly exercised and is akin to a forward contract with a delivery price equal to E. Thus, such a call would be expected to be priced at $S_0 - E e^{-rt}$. In the Black and Scholes formulation, large values of S_0 will result in large values of d_1 and d_2, and $N(d_1)$ and $N(d_2)$ would both be close to 1. For the put option, on the other hand, the large values of S_0 would result in a price close to zero.

2. An increase in the exercise price from Rs 115 to Rs 118 reduces the intrinsic value of the call option. Thus, the call premium reduces with this. The put option value, on the other hand, increases because at this exercise price, it is out-of-the-money to a lesser degree.

3. When the exercise price is taken to be Rs 125 against the stock price of Rs 120, the call option becomes out-of-the-money. Hence its value reduces. At this rate, the entire premium is on account of the time value. In contrast to the call option, the put option is in-the-money with an intrinsic value equal to Rs 125 – Rs 120 = Rs 5. Out of the total premium of Rs 14.93, the time value of the put option is Rs 14.93 – Rs 5 = Rs 9.93.

Table 5.6

Effect of Changes in Various Parameters

New Parameter Value	*Value of Option (In Rupees)*	
	Call	*Put*
Basic Data	18.11	10.27
$S_0 = 124$	20.78	8.94
$E = 118$	16.15	11.24
$E = 125$	13.02	14.93
$t = 4$ months	20.81	12.04
$r = 12\%$	18.40	10.00
$\sigma = 0.7$	20.34	12.50

4. Longer the duration of an option to maturity, greater is the time value of the option. Accordingly, both the call and the put option values are seen to be up with an increase in the duration from 3 to 4 months.

5. A rise in the riskfree rate of interest has a favourable impact on the call option price and unfavourable impact on the price of the put option. In the valuation of a call option, the riskfree rate of interest (r) is used in all the three expressions: for calculation of d_1, d_2 and Ee^{-rt}. It may be intuitively seen that the impact of an increase in the value

of r would be much less on d_1 and d_2, and therefore on $N(d_1)$ and $N(d_2)$, than on $E\,e^{-rt}$. The overall impact would, therefore, be to suppress the value of $E\,e^{-rt}$. Consequently, the call option value will show an increase. However, the impact of the change in r, cannot be traced directly for the put option value. An increase in the riskfree rate of interest, as indicated earlier, leads to an increase in expected growth rate in the stock option prices, on the one hand, and a decrease in the present value of any cash flows received by the holder of an option, on the other. Both these effects have an adverse impact on the value of the put options. Suffice to say, then, that the increase in the value of C, the call option price, is more than offset by a decline in the present value of the exercise price, $E\,e^{-rt}$, thus lowering the value of a put option.

6. An increase in the variability of the underlying asset value makes the options more valuable. This is evident from the values of call and put options contained in the last row of Table 5.6.

On the other hand, a decline in the variability would lead to a decline in the option values. When the variability, σ, approaches zero, the stock in question would be virtually riskfree. Accordingly, its price would grow at the rate r to $S_0\,e^{rt}$ after time t and the payoff from a call option at maturity would be $S_0\,e^{rt} - E$, or zero, whichever is higher. Discounting at the rate r, the present value of the call option works out to be the higher of the two: $S - E\,e^{-rt}$, and zero. Similarly, when σ tends to zero, the put option price would be the larger of $E\,e^{-rt} - S_0$ or zero.

The sensitivity results are summarised in Table 5.7.

Table 5.7

Sensitivity of Option Premium

Parameter	*Effect of an increase in value of each parameter on the option value, holding others constant*	
	Call option premium	*Put option premium*
1. Current Stock Price	Increase	Decrease
2. Exercise Price	Decrease	Increase
3. Time to expiration	Increase	Increase
4. Interest Rate	Increase	Decrease
5. Volatility	Increase	Increase

Volatility Revisited: Calculation of Implied Volatility It is clear that volatility of the underlying plays an important role in the Black and Scholes option pricing model. It is measured in terms of the standard deviation and used as an input in the formulation. A reference to the Black and Scholes formula reveals that sigma (σ) enters the equation several times. Now, just as we can calculate the option premium for a given set of inputs including standard deviation, it should be possible for us to calculate the standard deviation (σ) when all parameters, except this, are given along with (market) price of the option, and the Black and Scholes model is assumed to work. This is *implied volatility* in the given option premium. The objective of deriving implied volatility is to use it as an aid in forecasting the future volatility.

However, it is evident from the format of the equation that although σ appears repeatedly, it cannot be conveniently isolated. Thus, we cannot obtain the value of σ from the equation directly. We may obtain its value only by trial and error process.

Several attempts have been made to produce approximations to estimate the implied volatility but they lose their accuracy as the price of the underlying moves away from the exercise price. A solution provided by Corrado and Miller is given here, that produces values very nearly correct over a reasonable range of moneyness of the options. The rule is:

$$\sigma =$$

$$\frac{1}{\sqrt{t}}\left[\frac{\sqrt{2\pi}}{S_0 + Ee^{-rt}}\left(C - \frac{S_0 - Ee^{-rt}}{2} + \sqrt{\left(C - \frac{S_0 - Ee^{-rt}}{2}\right)^2 - \frac{(S_0 - Ee^{-rt})^2}{\pi}}\right)\right]$$

For the data in Example 5.3, where $S_0 = \text{Rs } 120$, $E = \text{Rs } 115$, $t = 0.25$, $r = 0.10$ and $C = \text{Rs } 18.11$, we have

$$S_0 + E\,e^{-rt} = 120 + 115e^{-0.1 \times 0.25} = 232.161$$

$$S_0 - E\,e^{-rt} = 120 - 115e^{-0.1 \times 0.25}$$

$$= 7.839$$

Further,

$$\sigma = \frac{1}{\sqrt{0.25}}\left[\frac{\sqrt{2\pi}}{232.161}\left(18.11 - \frac{7.839}{2} + \sqrt{\left(18.11 - \frac{7.839}{2}\right)^2 - \frac{(7.839)^2}{\pi}}\right)\right]$$

$$= 0.60$$

This indeed is the σ value used in calculating the call option value.

For an exactly at-the-money call option, however, we can get the implied volatility by applying the following formula:

$$\sigma = \frac{0.5\,(C+P)\sqrt{(2\pi/t)}}{E/(1+r)^t}$$

This can be seen with the help of an example.

Example 5.4

The following data are given:

Stock price	:	Rs 120
Exercise Price	:	Rs 120
Risk-free rate of interest	:	5% p.a.
Standard deviation of continuously compounded rate of return (σ)	:	0.20
Time to maturity	:	45 days

Calculate the call and put option values using these data. Now, using the same inputs and the call and put option values, verify that $\sigma = 0.20$.

Using the given information, the call and put option values may be calculated as equal to Rs 3.73 and Rs 2.99 respectively. Now, substituting the various input values in to the formula, we may calculate the implied volatility, σ, as follows:

$$\sigma = \frac{0.5(3.73+2.99)\sqrt{2\times 3.1416\times(365/45)}}{120/(1.05)^{45/365}}$$

$$= 0.20$$

Derivatives of Black and Scholes Formulation

Having considered broadly as to how the option premium is likely to be affected when some input value changes, we may now formally state the various measures of sensitivity. Mathematically, they may be obtained by differentiating the Black and Scholes formulation for call and put options, with respect to various input parameters, namely S_0, t, r, and σ. The derivatives include delta, gamma, theta, rho and vega. We consider these now.

Delta This is a very significant by-product of the Black and Scholes model and is used extensively in the context where options form part of the portfolios. The reason for this is that the deltas provide multi-fold information. Deltas are interpreted as (i) a measure of volatility,

(ii) a measure of the likelihood that an option will be in-the-money on the expiration day, and (iii) a hedge ratio.

As a measure of volatility of the option premium, delta refers to the amount by which the price of an option changes for a unit change in the price of the underlying security or index. Mathematically, it is equal to the partial derivative of the call option premium (C) with respect to the stock price (S_0) for a call option and partial derivative of the put option premium (P) with respect to the stock price (S_0) for a put. A delta equal to 0.7 for a call option implies that for a one unit change in the stock price (or index) the option would move 0.7 points. Similarly, a delta equal to – 0.8 for a put option means that the put option premium will decline by 80 paise if the underlying stock price rises by one rupee.

In terms of the Black and Scholes model, for a call option, the delta is given by $N(d_1)$, while for a put option it is equal to $N(d_1) - 1$. For Example 5.3, $N(d_1)$ being equal to 0.6443, the delta for call option is 0.6443 and for put option, it is $0.6443 - 1 = -0.3557$. Thus, if the price of the underlying share ABC, rises by Re 1, the price of call option will rise approximately 64 paise while the price of the put option will fall by about 35 paise. It should be noted, however, that these estimates of changes in the option values are only approximate. These values of deltas will give us exact changes only if the changes in stock price are infinitesimally small. Since a one-rupee (or some bigger amount) change in the price is discrete, the computed prices are only estimates.

Evidently, the call delta value would always be greater than zero and less than one, since $N(d_1)$ represents area under the standard normal curve. Deep in-the-money call options would have delta close to unity while deep in-the-money put options would show a delta nearing – 1. Options that are far out-of-the-money have delta values close to zero. Thus, while deep in-the-money options tend to move in tandem with the value of the underlying asset, the far out-of-the-money options show a very low response to such changes. An analysis of the changes in delta of an option reveals that if an option is at-the-money, the decline in delta is approximately linear over time, while for an out-of-the-money option, the delta declines and approaches zero as the time passes, the decline being more pronounced as time passes. On the other hand, in-the-money options behave like the underlying stock and approaches 1.0 as the date of expiration approaches. The delta changes most rapidly for the options that are near the money. Further, as an option moves from being out-of-the-money to in-the-money, the value of delta increases (ignoring the minus sign in case of put options), the increase being greatest for the smaller dated options.

Delta as a Probability Delta is also employed as a measure of the probability that a given option will be in-the-money on the expiration day. Thus, for the call option considered in Example 5.3, which has delta equal to 0.6443, we can say that there is nearly a 64.43 percent chance that the stock price on the expiration day will be above the option exercise price of Rs 115.

Delta as a Hedge Ratio In the Black and Scholes formulation, $N(d_1)$ also gives the optimal hedge ratio. This indicates how many units of the option are necessary to mimic the returns of the underlying stock (or other asset). For our example of *ABC* shares, $N(d_1) = 0.6443$. It implies that for every call option purchased, 0.6443 of the share of the stock should be sold short, and since a call option is (generally) for 100 shares, 64.43 shares of the stock should be traded for each call. Accordingly,

Number of shares of stock per call option = 64.43, and

Number of call options per 100 shares of stock = Rec $N(d_1)$ = Rec 0.6443 = 1.55.

Accordingly, if someone owned 1000 shares of the underlying stock, then writing 15.5 (that is 16) call option contracts would result in a theoretically perfect hedge for small changes in the stock price.

Creation of Delta-Neutral Positions To put the idea more formally, let us consider a portfolio consisting of a short position in one call (European) on a stock and long position in delta units of the stock. The value of this portfolio, P_1 would be:

$$P_1 = -C + N(d_1)\,S_0$$

With our example, where C = Rs 18.11, $N(d_1) = 0.6443$ and $S_0 = 120$,

$$P_1 = -18.11 + 0.6443 \times 120 = \text{Rs } 59.206.$$

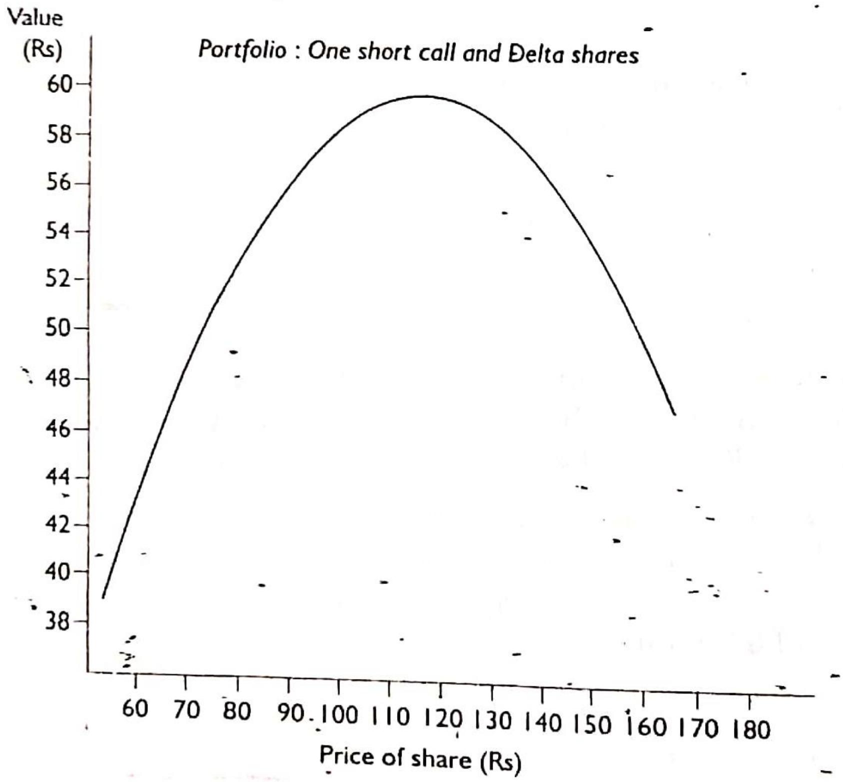
Now, if the stock price increases to Rs 121, the value of the portfolio would be

$$P_1 = -18.76 + 0.6443 \times 121 = \text{Rs } 59.200.$$

Thus, for a one-rupee change in the stock price, the value of the portfolio would change by only Rs 0.006. If the change in the price of the stock were infinitesimally small, then the portfolio value would not change at all, and if there is a large change in the stock price, the change in the portfolio value would be large. However, even for the substantial changes in the spot price of the stock, the changes in the portfolio value would be relatively small. To illustrate, if the stock price becomes Rs 130, the call price would become Rs 25.05 and the portfolio value would change as shown here:

$$P_1 = -25.05 + 0.6443 \times 130 = \text{Rs } 58.709.$$

Thus, here a Rs 10 change in the stock price brings about a Rs 0.497 change in the value of the portfolio. Figure 5.7 shows how the value of this portfolio changes with changes in the stock price.



➢ **Fig. 5.7** *Value of Delta-Neutral Portfolio*

This type of portfolio is termed as *delta-neutral portfolio* because for it, an infinitesimal change in the stock price does not produce a change in the portfolio value. Accordingly, for this portfolio, whose value is insensitive to small change in the price of stock, the delta is zero.

The Black and Scholes model is based on the assumption that the stock price changes continuously. Now, suppose that we can trade shares and options continuously (remember that delta changes with changes in stock prices) and rebalance our portfolio as stock price changes. In this rebalancing, we attempt to maintain the portfolio as a delta-neutral one. Thus, through continuous trading, we can keep our portfolio insensitive to stock price changes and, hence, risk-free. Such a risk-free portfolio should earn the risk-free rate of return.

The possibility of creating a delta-neutral portfolio is a very important one in shaping the risk profile of an investment. Thus, the stock in question may be very risky one and an investment in it may be made risk-free (delta-neutral) by using a call option as discussed earlier. Now, if the investor shorts not one, but one-half a call, then the risk would reduce, but it would not be completely eliminated. Thus, options can be used to modify the risk profile as desired.

The idea of creating delta-neutral portfolio is also important in using delta-oriented hedging strategies. The principles of hedging a single option discussed earlier can be applied as well, when a portfolio consisting of multiple options is held. In case of multiple options, the first step required is the calculation of position delta and then a hedge is created such that the position is delta-neutral.

The position delta is calculated as the weighted average of the deltas of the options held. The respective weights for various options are given by the proportionate values of the options in the total portfolio. The deltas are given positive signs for long call and short put positions, and negative for short call and long put positions. Evidently, to be meaningful, each position in the options must be on the same underlying asset although the position can include calls and puts, long and short positions, and with options involving different exercise prices and expiry dates.

Once the position delta is calculated, position in the underlying asset can be taken to make the option delta-neutral. To illustrate, if the option position had a net delta of + 0.7, then such position would be made delta-neutral by going short the underlying asset to the extent of 0.7 or 70% of the notional value of the assets represented by the option position. Thus, if the option position consisted of calls on 40,000 shares, going short 28,000 shares will make the position instantaneously delta-neutral. In terms of the Black and Scholes model, it would be possible continuously to rebalance the portfolio by altering the short position in the underlying asset to ensure that the portfolio remains delta-neutral.

Gamma The gamma represents the amount by which an options delta would move in response to a unit change in the underlying stock price or index (in language of calculus, gamma is the second derivative of the option price with respect to the stock price, S_0). Thus, it measures the proportional change in delta for a given change in the underlying asset value. A movement of delta from 0.6 to 0.7 in relation to a unit change in the underlying index, for instance, yields a gamma equal to 0.1. For an at-the-money option, gamma increases as the time to maturity decreases. Short life at-the-money options would have very high gamma values implying thereby that the value of the option holder's position is very sensitive to jumps in the stock price.

The gamma of a call option is always equal to the gamma of a put option and it can be either positive or negative. In the Black and Scholes formulation, gamma is calculated as follows:

$$\text{Gamma} = \frac{z(d_1)}{S_0 \sigma \sqrt{t}}$$

where

$$z(d_1) = \frac{e^{-d_1^2/2}}{\sqrt{2\pi}}$$

For our example, (Example 5.3), we have $S_0 = 120$, $\sigma = 0.6$, $t = 0.25$ and $d_1 = 0.37$. Accordingly,

$$z(d_1) = \frac{e^{-d_1^2/2}}{\sqrt{2\pi}} = \frac{e^{-(0.37)^2/2}}{\sqrt{2\pi}} = 0.3725$$

$$\text{Now, Gamma} = \frac{z(d_1)}{S_0 \sigma \sqrt{t}} = \frac{0.3725}{120 \times 0.6 \times \sqrt{0.25}} = 0.0103$$

Here gamma equal to 0.0103 has the implication that an increase in the stock price of Re 1.0 will increase the call delta by 0.0103. With $S_0 = 120$, the call delta at present is 0.6443. If the stock price were to rise from Rs 120 a share to Rs 121, the delta would increase to 0.6546.

Similarly, for the put option, the delta = – 0.3557 would change to – 0.3557 + 1(0.0103) or – 0.3454, with a one-rupee change in the stock price from Rs 120 to Rs 121.

Theta The theta is obtained by considering value of an option as a function of time when all other parameters of the pricing model remain constant. It is thus known as the *time decay* of the option value. Theta represents the price decay that affects an option as it ages and loses time value. It is nearly always negative for an option because as the time to maturity approaches, the option tends to become less valuable. In exhibits greatest effect before close to the expiration of the option.

Defined as the negative of the derivative of the option price with respect to time remaining until expiration, theta is obtained as follows:

For a call option

$$\text{Theta} = -\frac{S_0\, z(d_1)\sigma}{2\sqrt{t}} - E\,e^{-rt}\, r\, N(d_2)$$

For a put option

$$\text{Theta} = -\frac{S_0\, z(d_1)\sigma}{2\sqrt{t}} + E\,e^{-rt}\, r\, N(-d_2)$$

where

$$z(d_1) = \frac{e^{-d_1^2/2}}{\sqrt{2\pi}}$$

Continuing with the data of Example 5.3, where $S_0 = 120$, $\sigma = 0.6$, $t = 0.25$, $E = 115$, $r = 0.10$, $d_1 = 0.37$ and $d_2 = 0.07$, we have

$$z(d_1) = \frac{e^{-d_1^2/2}}{\sqrt{2\pi}} = \frac{e^{-(0.37)^2/2}}{\sqrt{2\pi}} = 0.3725$$

Accordingly,

$$\text{Theta (call)} = -\frac{120 \times 0.3725 \times 0.6}{2\sqrt{0.25}} - 115 \times e^{-0.10 \times 0.25} \times 0.10 \times 0.5279$$

$$= -26.82 - 5.92$$

$$= -32.74$$

$$\text{Theta (put)} = -\frac{120 \times 0.3725 \times 0.6}{2\sqrt{0.25}} + 115 \times e^{-0.10 \times 0.25} \times 0.10 \times 0.4721$$

$$= -26.82 + 5.30$$

$$= -21.52$$

Note here that these values of theta are expressed in terms of years. A theta equal to – 32.74 suggests that if time to expiration were a year longer, then the value of the call shall be up by about Rs 32.74. Thus, with an expiration of one year and three months, the call would sell for Rs 18.11 + Rs 32.74 = Rs 50.85. It may be mentioned here that since the partial derivative evaluates changes in the call price for small changes in time, it is more accurate, as also desired, that we express the time decay as about Re 0.09 per day (obtained as Rs 32.74/365). It may be interpreted to mean that a day nearer to maturity would cause a fall of 9 paise in the price of the call option. Similarly, the put option would experience a fall of about (Rs 21.52/365) or 6 paise per day for each passing day towards maturity.

For stock prices near the exercise price, both the theta values would be quite negative as expiration approaches. However, the two thetas change differently accordingly as the options are in-the-money or out-of-the-money.

Rho The rho, which is the first derivative of an option's price with respect to the interest rate, measures the sensitivity of an option value to interest rate. This refers to the rate of change of the value of the option with respect to a unit change (say one per cent) in the interest rate.

Generally, the option values are not very sensitive to the changes in interest rates. For call options, rho is always positive while for put options, it is negative.

For a call option

$$\text{Rho} = Et\, e^{-rt}\, N(d_2)$$

For a put option

$$\text{Rho} = -Et\, e^{-rt}\, N(-d_2)$$

With $E = 115$, $t = 0.25$, $r = 0.1$ and $d_2 = 0.07$, for our example, we have

$$N(d_2) = 0.5279, \text{ and}$$

$$N(-d_2) = 0.4721.$$

Now,

$$\text{Rho (call)} = 115 \times 0.25 \times e^{-0.1 \times 0.25} \times 0.5279$$

$$= 14.80$$

$$\text{Rho (put)} = -115 \times 0.25 \times e^{-0.1 \times 0.25} \times 0.4721$$
$$= -13.24$$

The value of rho for call indicates that an increase in the return from 0.10 to 1.10 (10 to 110%) would cause the call option price to rise by Rs 14.80. Like in the case of time changes, it is desirable here to re-express changes consequent upon small changes in the interest rates. Accordingly, an increase in the risk-less interest rate from 10 to 11 percent would result in an increase in the value of call equal to Re 0.1480, or about 15 paise. Similarly, for the put option, the rho value −13.24 implies that an increase in the risk-free interest rate from 10 to 11 percent would result in a fall in the put option value equal to about 13 paise.

Vega Also known as *kappa* or *lambda*, vega measures the rate of change of the value of an option with respect to the volatility of the underlying stock. Vega is always positive and identical for call and put options. For the Black and Scholes model, Vega $= S_0\sqrt{t}\ z(d_1)$ in which $z(d_1)$ is obtained as $z(d_1) = \dfrac{e^{-d_1^2/2}}{\sqrt{2\pi}}$

In practice, volatility of the asset underlying a derivative security may not remain constant and may vary over time. This means that the value of the derivative security (the option) may change not only because of the change in the asset price but also because of movements of volatility over time. A high vega suggests that the option value is very sensitive to small changes in volatility, while a low vega implies that volatility changes over time cause relatively insignificant impact on the option prices.

For the data in Example 5.3, the vega may be obtained as under:

$$\text{Vega} = S_0\sqrt{t}\ z(d_1)$$
$$= 120 \times \sqrt{0.25} \times 0.3725$$
$$= 22.35$$

This value indicates that if σ changes from 0.6 to 0.7, the call value shall be up by Rs 2.235 (since a change from 0.6 to 1.6 causes the price to increase by Rs 22.35 as given by vega) to Rs 20.35, while a decline in σ from 0.6 to 0.5 would cause the price to fall by Rs 2.235 to Rs 15.88. The put option values would also change similarly.

DIVIDENDS, SHARE SPLITS AND BONUS SHARES

The payment of dividends, the splitting of shares and the issue of bonus shares during the currency of options affect the option prices. We shall now consider each of these in turn.

Dividends The options traded in the exchanges are usually not adjusted for the cash dividends payable on the underlying shares. Since the payment of cash bonus has an effect on the share prices, the option premia are also affected. We have already mentioned earlier in this chapter that the payment of dividends affect the price of options.

To understand the idea, let us recall that price of a share at a given point in time in equal to the present value of all dividends receivable on it in future. Thus, today's price of a share represents the present value of all dividends obtainable after today and its price at the expiration of a call would be the present value of all dividends obtainable subsequent to that day. The difference between the two prices is the present value of dividends between today and and the expiration date. Now, assuming that the dividends during the currency of the option are known with certainty, the share trades ex-dividend prior to expiration, and the ex-dividend day and the payment day are the same, the value of the call option using Black and Scholes formula may be obtained by taking the share price adjusted for the present value of the dividend(s) during the life of the option. Subtracting the present value of the dividends from the stock price has the effect of reducing the value of the call option and increasing the value of the put option.

Example 5.5

Reconsider the Example 5.3. Suppose that a dividend of Rs 2.50 will be received from the underlying share 40 days from today. You are required to calculate the values of the call and the put options in light of this information.

The inputs given are: $S_0 =$ Rs 120, $E =$ Rs 115, $t = 0.25$, $r = 0.10$, $\sigma = 0.06$ and a dividend of Rs 2.50 after 40 days. We first calculate the present value, D_0, of Rs 2.50 obtainable after $t = 40/365$, as follows:

$$D_0 = D\, e^{-rt}$$
$$= 2.50\, e^{-0.10 \times 40/365}$$
$$= \text{Rs } 2.47$$

The present value of share, S_0, adjusted for the present value of dividend, D_0, equals $S_0^* = S_0 - D_0 =$ Rs 120 – Rs 2.47 = Rs 117.53. Substituting this value of S_0, we can obtain the call option value as follows.

Calculation of $N(d_1)$ and $N(d_2)$:

$$d_1 = \frac{\ln(117.53/115)+(0.10+0.5\times0.6^2)(0.25)}{0.6\sqrt{0.25}} = 0.31$$

Therefore, $N(d_1) = N(0.31) = 0.5 + 0.1217 = 0.6217$

$$d_2 = \frac{\ln(117.53/115)+(0.10-0.5\times0.6^2)(0.25)}{0.6\sqrt{0.25}} = 0.06$$

Accordingly, $N(d_2) = N(0.06) = 0.5 + 0.0239 = 0.5239$

Now,

$$C = S_0^* N(d_1) - E\,e^{-rt} N(d_2)$$

$$= 117.53 \times 0.6217 - \frac{115}{e^{0.10(0.25)}}(0.5239) = \text{Rs } 14.31$$

Now, the put option premium can be calculated as follows:

$$P = C + E\,e^{-rt} - S_0^* \quad 0.25$$

$$= 14.31 + 115 \times e^{-0.1 \times 40/365} - 117.53$$

$$= \text{Rs } 10.53$$

Stock Splits The options traded on exchanges are adjusted for the stock splits. Recall that a stock split occurs when existing shares of a company are split into a greater number of shares. A stock split occurs, for instance, when a company which has its capital divided in shares of Rs 100 each, decides to convert the capital into shares of denomination of Rs 10 each. In such a case, a 10-for-1 split occurs and 10 new shares are replaced for each existing share. Since a stock split does not affect the assets or the earning capacity of the company in any way, the wealth of the shareholders does not change. Other things remaining the same, a 10-to-1 split would cause the price of the share to be one-tenth of what it was before. Thus, any stock split would be expected to affect the price of the share proportionately. The terms of the options are adjusted to take account of any stock splits so as to reflect the expected price changes resulting therefrom. In general terms, for an b-to-a stock split, the exercise price is reduced to a/b of the original value while the number of shares are increased to b/a of the previous value. It goes without saying that in a given case, if the share price moves as expected, the positions of the buyer and the seller remain unchanged.

Example 5.6

A call is purchased to buy 100 shares at Rs 90 per share. Suppose that during the currency of the option, the company split the stock in the ratio of 5-to-2. This would cause the terms of the contract of change so that the writer will be obliged to deliver 250 (= 100 × 5/2) shares @ Rs 36 (= 90 × 2/5) per share on demand.

Bonus Shares Like in case of splitting of shares, the issuance of bonus shares also is adjusted for in the options contracts. The bonus shares imply that more shares are being issued to the existing shareholders. The issue of bonus shares, like the splitting of shares, does not affect the assets or the earning capacity of the company and the price of the shares of the company is likely to fall down. If the shareholders of a company receive 2-for-5 bonus shares, it implies that a shareholder would get two equity shares as bonus for every five shares held by him/her in the company. This is equivalent to a 7-to-5 splitting of the shares. Accordingly, other things being the same, the stock price would decline to 5/7th of its previous value. The terms of an option are adjusted to reflect the expected price decline arising from a bonus shares issue in the same manner as emanating from the splitting of shares.

Example 5.7

In respect of a call option to buy 100 shares of a company at Rs 60, suppose that the company involved issues 20% bonus shares (so that for every five shares held by a shareholder, one share is given as a bonus). This is equivalent to a 6-to-5 stock split. Accordingly, the terms of the options contract are changed, so that it gives the holder of the call option, the right to buy 120 shares of the company at a price of Rs 50.

LIMITATION OF BLACK AND SCHOLES MODEL

It may be noted that the Black and Scholes option pricing model works well for options that are near the money and for options with next striking price on either side of the stock price. However, it does not yield satisfactory results for options that are deep in-the-money or out-of-the-money. Similarly, it has been found that the model does not yield unbiased values in respect of stocks with very high or very

EXERCISES

1. Why are American calls likely to be more valuable than the comparable European calls?
2. How are valuations of call options in respect of a stock likely to be affected by (i) different exercise prices, and (ii) lengths of time to expiration? Consider two calls with the same time to expiration that are written on the same underlying stock. The first call trades for Rs 8 and has an exercise price of Rs 95, while the second call has an exercise price of Rs 90. What is the maximum price that the second call would have? Explain.
3. Graphically depict the valuation of (i) call, and (ii) put options.
4. Show that the minimum value of a European call option shall be at least equal to the difference between the stock price and the present value of the exercise price.
5. Explain the principle of put-call parity.
6. Trace the effect of a dividend payable on the underlying share on the call and put prices.

7. Discuss the various factors affecting the prices of options. Also indicate as to how each of these would affect the price of
   (i) a call option, and (ii) a put option.
8. How do the call and put prices vary with interest rates? Also, explain in intuitive terms, the relationship between risk of the underlying stock and the option prices.
9. Discuss the binomial model for the valuation of options. Why is it called 'binomial'?
10. State the assumptions underlying the Black and Scholes model.
11. Explain the calculation of the standard deviation of the distribution of continuously compounded rate of-return on the stock for use as a measure of volatility in the Black and Scholes formulation.
12. State the Black and Scholes formula for the valuation of European call options. How can the put option with the same parameters as a call option can be valued?
13. What do you understand by implied volatility? How can it be calculated?
14. Discuss the sensitivity of the B-S formulation to changes in the input values.
15. A share price is currently Rs 50. Assume that the end of six months it will be either Rs 60 or Rs 42. The risk-free rate of interest with continuous compounding is 12% per annum. Calculate the value of a 6-month European Call option on the stock with exercise price of Rs 48.
16. Using binomial pricing model, obtain the hedge ratio, α, and the call price from the following data:
    Share price = Rs 70; Exercise price = Rs 75 $u = 1.2$; $d = 0.9$; $i = 1.2$; and $N = 3$.
17. Determine the value of a call option using the Black and Scholes model:
    The share is currently selling at Rs 80 and the standard deviation of the stock's instantaneous rate of return is 0.7. The call has an exercise price of Rs 90 and has 6 months to go for expiration. The continuously compounded risk-free rate of return is 8% per annum.
18. (a) Using Black and Scholes formula, calculate the value of a European call option using the following data:
    Exercise Price = Rs 100
    Stock Price = Rs 90
    Time to expiration = 6 months

Continuously compounded risk-free rate of return = 10% per annum

Variance of continuously compounded rate of return = 0.25

(b) By *Put-Call Parity*, determine the value of Put option using data in (a) above.

19. You are given the following data on a certain share and a call option on the stock:

Share Price	Rs 67
Exercise Price	Rs 65
Time to Expiration	3 months
Risk-free Rate of Return (Continuously compounded)	8% per annum
Variance of Stock's Return	0.36

(i) Calculate the value of the option using the Black and Scholes model.

(ii) If this option is priced at Rs 7.50, what investment strategy would you suggest?

(iii) Use your answer in part (i) to calculate the value of a put option with identical exercise price and time to maturity.

20. Using the Black and Scholes model and the principle of put-call parity, obtain the values of call and put options from the following data:

Price of the Share	Rs 124
Exercise Price	Rs 130
Time to Maturity	4 months
Risk-free Rate of Return	12% per annum

Standard Deviation of the distribution of the continuously compounded rate of return on the stock = 0.5. Also state whether each of the options is in-the-money or out-of-the-money, and decompose the values of each one into intrinsic value and time value.

21. From the following data, obtain the call and put option values based on Black & Scholes' formulation:

Stock price	= Rs 206
Exercise price	= Rs 200
Time to expiration	= 47 days
Standard-deviation of the continuously compounded rate of return on stock	= 0.26
Continuously compounded rate of return	= 8%

Also obtain the values of various greeks.

22. How would the option values change in Exercise 21, if a dividend of Rs 12 per share is expected to be received in 12 days' time?

23. Examine the effect of each of the following changes on the call and put option values in Exercise 21:
    (a) The stock price increases by Rs 8.
    (b) The standard deviation of the return is changed to 0.30.
    (c) The risk-free rate of return reduces by 2 percent.

24. From the information given below, estimate the volatility implied:

Stock price	= Rs 126
Exercise price	= Rs 132
Time to maturity	= 45 days
Risk-free rate of return	= 8%
Call premium	= Rs 3.30

Recalculate the volatility if the stock price matches with the exercise price.

❖ SWAPS

Introduction

- A swap is a method for reducing financial risks. Swap is an exchange, and in financial jargon it is an exchange of cash payment obligations, in which each party to the swap prefers the payment type or pattern of the other party.
- In other words, swap occurs because the counter parties prefer the terms of the other's debt contract, and the swaps enables each party to obtain a preferred payment obligation.
- Generally, one party in the swap deal has a fixed rate obligation and the other party in the same deal has a floating rate obligation, or one has an obligation denominated in one currency and the other in another currency.

Meaning

- 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.
- The two commonly used swaps are:
    - **Interest rate swaps**: These entails swapping only the interest related cash flows between the parties in the same currency.
    - **Currency swaps**: These entail swapping both principal and interest between the parties, with the cash flows in one direction being in a different currency than those in the opposite direction.

- **Swaptions**:

- Swaptions are options to buy or sell a swap that will become operative at the expiry of the options.
- Thus, a swaption is an option on a forward swap. Rather than have calls and puts, the swaptions market has receiver swaptions and payer swaptions.
- A receiver swaption is an option to receive fixed and pay floating.
- A payer swaption is an option to pay fixed and receive floating.

- **Swap Terminology**

- **Parties**: Generally, there are two parties in a swap deal, and this excludes the intermediary. For example, in an interest rate swap, the first party could be a fixed rate payer/receiver and the second party could be a floating rate receiver/payer.

- **Swap Facilitators**: Swap facilitators are generally referred to as 'Swap Banks' or simply 'Banks'. There are two kinds of swaps facilitators i.e., Swap Broker and Swap Dealer.

- **Swap Broker**: Also known as an intermediary, a swap broker as an economic agent helps in identifying the potential counterparties in a swap deal. The swap broker only acts as a facilitator charging a commission for his services and does not take any individual position in the swap contract.

- **Swap Dealer**: Swap dealer associates himself with the swap deal and often becomes an actual party to the transaction. Also known as 'market maker', the swap dealer may be actively involved as a financial intermediary for earning a profit.

- **Notional Principal**: The underlying amount in a swap contract which becomes the basis for the deal between counterparties is known as the notional principal. It is called 'notional' because this amount does not vary, but the cash flows in the swap are attached to this amount. For example, in an interest rate swap, the interest is calculated on the notional principal.

- **Trade Date**: The date on which both the parties in a swap deal enter into the contract is known as trade date.

- **Effective Date**: It is also known as Value Date: This is the date when the initial cash flows in a swap contract begin (e.g. initial fixed and floating payments, for interest rate swaps). The maturity of a swap contract is calculated from this date.

- **Reset Date**: Reset date is that date on which the LIBOR rate is determined. The first reset date will generally be two days before the first payment date and the second reset date will be two days before the second payment date and so on.

- **Maturity Date**: The date on which the outstanding cash flows stop in the swap contract is referred to as the maturity date.