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(FINANCIAL INVESTMENT ANALYSIS)

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Financial Derivatives

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UNIT - I

LESSON

1

Introduction to Derivatives

STRUCTURE

1.1 Learning Objectives

- Comprehending the basics of financial derivatives markets.
- Understanding different types of financial derivatives.
- Learning various margins applied in financial markets.

1.2 Introduction

When it comes to finance, derivatives have grown in importance over the last 40 years. Futures and options are sold on exchanges around the world. Banks, fund managers, and business treasurers use the over-the-counter market to make a wide range of forward contracts, swaps, options, and other derivatives. Derivatives are used in executive pay plans, added to bond issues, built into capital investment possibilities, to shift mortgage risk from the original lenders to investors, When it comes to the assets that are traded, the swaps market is much bigger than the stock market. A few times the world's GDP is equal to the value of the assets that back up outstanding derivatives deals. You can say that a derivative is a financial instrument whose value is based on or comes from

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the values of other assets whose price is discovered in the markets on an ongoing basis. One type of derivative is a stock option, whose value changes based on the price of a stock. The value of these contracts is based on changes in the underlying asset's price, interest rates, or other factors. Derivatives are financial tools that let traders and buyers bet on or protect themselves against changes in price in that asset in the future.

Credit derivatives, energy derivatives, weather derivatives, and insurance derivatives can all now be bought and sold. A lot of new types of derivatives for interest rates, foreign exchange, and stocks have been made. A lot of new ideas have come up on how to measure and control risk. When evaluating a capital investment, people often look at what are called "real options."

Derivatives markets had a role to play in the 2007-2008 credit crisis. In the US, derivative securities were made from groups of risky mortgages through a process called securitization. When home prices dropped, a lot of the things that were made lost their value. Derivatives are used to control risk, speculate, hedge, and arbitrage on the financial market. They let people in the market manage their exposure to price changes, make investments with borrowed money, and change financial tools to fit their specific needs. While derivatives can be useful tools, they also come with risks, such as market instability, counterparty risk, and the chance of losing a lot of money. When working with derivatives, it's important to understand them well, handle risks, and keep an eye on what the government is doing.

1.3 History of Derivatives Market in India

Indian derivatives trading started informally in the 1960s with the start of trading in commodities futures. During this time, however, there were not many formal rules or trading sites. It wasn't until the 1990s that the Indian government looked into how derivative markets could help institutions control risk and bring in foreign investment. SEBI played a significant role in setting up the futures market and making sure that it was transparent, secure, and worked properly.

Index-based contracts like the S&P CNX Nifty were first traded on the National Stock Exchange of India (NSE) in June 2000. This was the start of index futures trading. In India's derivatives market, new goods have been added over the years, such as stock futures, stock options, index options, and currency derivatives. These goods gave people in the market a lot of different tools for dealing with risk, speculation, and arbitrage.

SEBI made a number of changes to the rules in order to improve the way the futures market works and protect investors' interests. These changes included strict rules for managing risk, margin requirements, position limits, and ways to keep an eye on things to stop market abuse and too much speculation. SEBI let people trade interest rate futures (IRFs) on Indian stock exchanges in 2003. This let people in the market protect themselves against interest rate risks. The goal of this change was to make the bond market stronger and give market players more tools for managing risk.

The Indian derivatives market grew quickly and saw new products come out. More big investors, foreign portfolio investors (FPIs), and retail traders joined. The market became even more liquid and efficient as new goods, trading platforms, and technology-based projects were introduced.

Even though it's growing, India's swaps market still has problems, such as following the rules, unstable markets, worries about liquidity, and problems with managing risk. But because of ongoing reforms, improvements in technology, and more people becoming aware of the market, the future picture for the derivatives market is still positive, with room for more growth and development.

1.4 Margins

Trading derivatives for speculation can make traders more vulnerable to market risk. Changes in market conditions, such as the price of an asset, interest rates, market volatility, and market liquidity, can make it hard to predict how much money one may make or lose from trading. Specifically in derivatives where trader is exposed to a position much larger than the money he has invested. To keep the trader's skin in game so they don't default in case of unfavourable price movements, margin requirements were introduced. Margining systems deal with the uncertainty that leads to risk of default.

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Let's say a person buys 1000 shares of the "xyz" company for 100 rupees each 1 January 2024. The amount an investor has to pay to buy something is Rs. 1,000,000/-.(1,000 times 100) to his broker by January 2, 2024, at the latest. In turn, Broker has to give this money to the stock exchange on January 3, 2024.

There's always a small chance that the owner won't be able to bring the needed to pay money by a certain date. As a down payment on buying shares, the trader has to pay the broker a part of the total amount of Rs. 1,00,000/- when the order is placed. In turn, the stock market gets the same amount from the broker as soon as the order is carried out. This small payment at the beginning is called margin.

Note that there is always a selling party to a buying party and if the buyer doesn't bring the required money the seller might not get his share of money. Similarly, there is a risk that the seller may default on providing shares hence seller also has to pay margin to make sure they give the broker the 100 shares they sold, who then gives them to the stock exchange. Market gives a way to figure out how much risk the market maker and traders are taking on. Value at Risk, which is an estimate of possible losses, is the most common way to measure market risk. SEBI, the market regulator, has issued a directive that all clearing and trading members must collect margin ahead from clients who want to trade in the derivatives segment.

1.4.1 *VaR Margin*

Value at risk, or VaR, is the largest expected loss that one could have over a certain time period, based on a certain confidence range. Value at Risk, or VaR, is a way to figure out what the biggest losses might be over a certain period. Volatility in the past tells us how the price of an investment changed over time. VaR tells "How much is a security or portfolio likely to change in the next day?"

VaR is a way to figure out how likely it is that security will lose value. There are three parts to a VaR statistic: a period, a confidence level, and a loss. Remember these three parts and find them in this example: "With 99% certainty, what is the most an asset could be worth & might lose the next day? This "VaR question" has three parts, as you can see: a fairly high level of 99% confidence, a time frame (one day), and an estimate of the loss (which can be written in terms of dollars or percentages).

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Analysts want to make a statement about when they use the value-at-risk measure: It's a sure thing that no more than "V amount of dollars" may be lost in the next N days. The value of V is the portfolio's value at risk. It's the amount of money that could be lost over the next N days that has a (100 - X) % chance of happening. If N days is the time frame and X% is the level of confidence, then VaR is the amount of money that could be lost that is one-hundredth of the way that the portfolio's value goes up over the next N days. The parametric method, which is also called the variance-covariance method, says that the returns are likely to follow a normal distribution. It uses two things to figure out the VaR: the expected returns and the standard deviation. However, this method doesn't work for small sample sizes, which is its main flaw.

Let's say you are in charge of an investment portfolio worth Rs. 10,000,000 and you want to find the VaR with 95% confidence over a one-day horizon. This means you want to find the biggest loss that your portfolio could have over the next day with 95% confidence (z-score of about 1.645). To find VaR, you need to know how your portfolio or the appropriate market index has done in the past. For example, let's say that the standard deviation of the portfolio's daily returns is 2% based on past data. The formula for VaR is:

VaR = Portfolio Value *z * Std Dev

VaR = 10,000,000*1.645*0.02 = 32,900 rupees

1.4.2 *Extreme Loss Margin*

The extreme loss cushion is meant to cover losses that might happen outside of cover for VaR gaps. For every stock, extreme loss margin is computed as higher of 1.5 times change in the stock price's daily natural log returns over the last six months and 5% of value of portfolio.

This extreme margin rate is set by exchange at the start of each month by looking at price data from the last six months on a daily basis. Let's take a numerical illustration: Var margin is 13%. Let's say that the security's daily LN returns have a standard deviation of 3.1%. If you multiply 1.5 by the standard deviation, you get 4.65. In this case 5%, which is a rate that is higher than 4.65% will be used as the Extreme Loss margin rate. This means that the total margin on the security would be 18% (13% VaR Margin & 5% EL margin). That's Rs. 1,80,000/- for a portfolio worth 10 lakhs.

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1.4.3 *SPAN Margin*

SPAN (Standard Portfolio Analysis of Risk) margin is a system used by derivatives exchanges to calculate margin requirements for futures and options contracts. The SPAN margin system is designed to ensure that traders have sufficient funds in their accounts to cover potential losses from adverse price movements in the underlying assets. The stock exchanges have a standardized formula for calculating the span margin. A software called the Standard Portfolio Analysis of Risk (SPAN) calculates margin requirements for F&O trades in India in commodities, equities, and currencies. The term 'Span Margin' has been derived from the name of this software only. A fixed system calculates the span margin to account for the worst possible movement in the price of an underlying security. It's done by assessing various security factors that define potential loss or gain for an F&O contract under the given circumstances. These risk factors include price changes due to market volatility, theta decay, etc.

The span margin may be different for each asset, depending on the overall risk of that security. For example, when trading F&O contracts with shares as underlying assets, the span margin is usually higher than when trading F&O contracts with indexes as underlying assets. Also, the less volatile a security is, the lower the span margin requirement is, and vice versa.

1.4.4 *Initial Margin & Maintenance Margin*

Investors must leave a certain amount of money or collateral with their broker before they can open a new position in a futures or options contract. This is called initial margin. It is a form of protection or security deposit that covers possible losses that may happen if the trader's position goes against them. This margin requirement is usually a percentage of the total value of the position. It is set by the exchange or the regulatory body. The initial margin's purpose is to make sure that traders have enough money to meet their commitments and lower the risk of default.

Maintenance margin call is made to make sure that the least amount of margin is maintained by trader in their account in order to keep their position open. A trader will get a margin call from their broker if the value of their position goes below the maintenance margin level because of unfavourable price changes. A trader who gets a margin call must either add more money to their account to raise the margin level or close out part of their position to lower their risk.

It's a regulatory requirement set by brokerage firms and exchanges to ensure that investors have enough equity in their accounts to cover potential losses and meet margin calls.

When an investor buys securities on margin, they are essentially borrowing funds from their broker to finance the purchase. The initial margin requirement specifies the minimum percentage of the total purchase price that the investor must provide in cash or eligible securities. Maintenance margin, on the other hand, is the ongoing requirement to ensure that the value of the securities in the account, minus any borrowed funds, remains above a certain threshold.

If the value of the securities in the margin account falls below the maintenance margin level due to market fluctuations, the broker may issue a margin call, requiring the investor to deposit additional funds or securities into the account to bring it back up to the required level. Failure to meet a margin call can result in the broker liquidating some or all of the securities in the account to cover the shortfall.

Maintenance margin requirements vary depending on the type of securities held in the account and the policies of the brokerage firm and the exchange. They are typically expressed as a percentage of the total value of the securities held in the account. Higher-risk securities or more volatile market conditions may require higher maintenance margin levels to account for increased market risk.

IN-TEXT QUESTIONS

1. What does VaR margin represent in financial markets?

(a) The maximum loss a trader is willing to incur

(b) The minimum margin required to open a position

(c) The potential loss that might occur due to adverse market movements

(d) The minimum profit expected from a trade

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1.5 Type of Derivative Instruments

In the recent past, there has been a proliferation of derivative instruments in the market with varying characteristics to meet peculiar needs of trader and investors out there. Derivative instruments can broadly be classified as Forwards, Futures, Options & Swaps.

1.5.1 *Forward Contracts*

Forward contracts are deals to buy or sell an underlying asset at a certain time and price in the future. A spot deal, on the other hand, is an agreement to buy or sell an asset right away. Forward contracts are bought and sold on the over-the-counter market. They are tailor-made to meet the needs of both parties. Usually, they are between two banks or between a bank and a client.

In a forward contract, one party takes a long position and agrees to buy the underlying object at a certain price on a certain date in the future. There is another party that signs up to be short and agrees to sell the underlying at the same price and on the same date. The underlying asset can be a foreign currency, a commodity, stock, stock index, bond etc. A lot of people use forward contracts for foreign exchange. If traders want to reduce the risk of price changes, they can fix the price in a forward contract or hedge their current exposure to price changes. For instance, if a company agrees to buy £1 million for $1,553,000 in three months, this is called a forward contract. At the end of three months, if the spot exchange rate went up to, say, 1.6000, the forward contract would be worth $46,800 to the company, which is the difference between $1,600,000 and $1,553,200. At that rate, £1 million could be bought for 1.5532 euros instead of 1.6000 euros. Also, if the spot exchange rate dropped to 1.5000 at the end of the six months, the forward contract would lose $53,200 in value for the company because it would have cost them $53,200 more than the market price for the pound.

In general, if one is long in a forward contract for one unit of an asset, he will make profit if price at the time of maturity of contract is higher than the strike price which is pre-determined in the forward contract i.e. $S_T - K$, where K is the strike price and S_T is the spot price of the asset at the time the contract matures. This is because the person who has the deal has to buy something worth S_T for K. In the same way, if you are short in a forward contract for one unit of an asset, you will get K - S_T. Pay Off Diagram for long forward party is depicted in Figure 1.1.

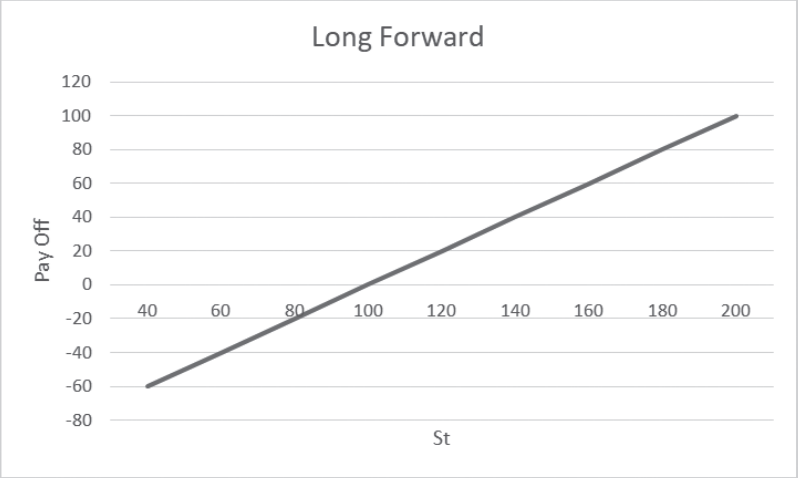

Figure 1.1: Payoff Diagram for Long Forward Contract

1.5.2 *Future Contracts*

Much like forward contract, a futures contract is an agreement between two parties to long or short an underlying asset at a certain time in the future for a certain price. Unlike forward contracts, futures contracts are normally traded on an exchange. Futures are exchange traded contracts as the underlying asset, future price and time to maturity of contract is stated by the exchange. For example, Buying September gold futures at Rs. 7000 per gram, gold trader has locked his price of gold if he liquidates his position in September itself as any price rise in gold spot price in September will be offset by gains made on gold futures.

There are significant similarities between futures and forwards contracts, as both provide a way to lock price of underlying asset and mitigate market risk. A variety of underlying assets, such as commodities, currencies, stocks, interest rates, and more, can serve as the foundation for forwards and futures contracts. Both contracts frequently require an initial margin or collateral from both parties to ensure performance and lower counterparty risk.

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While there are some parallels between forwards and futures contracts, it's important to keep in mind that they also differ greatly from one another. The primary areas of variance are exchange trading, standardization, counterparty risk, liquidity, and flexibility which is available in a futures contract as opposed to a forward contract. Further the future contracts are marked to market and cash settled on daily basis. Refer to Chapter 2 for detailed discussion on Futures.

1.5.3 *Options Contract*

Option contract provides holder with a right to buy or sell an underlying asset at certain price at a certain time in future. The party that buys the option is known as option holder while the one that sells the option is known as option writer. Option contracts are both traded on exchanges or in over the counter market. Option that provides holder with a right to buy an underlying asset at certain price at a certain time in future is known as call option while the one that provides holder with a right to sell an underlying asset at certain price at a certain time in future is known as put option. Option contracts can further be classified as American option & European options. The contracts that may be exercised on or before maturity date by the option holder are known as American option while the ones that can only be exercised on the date of maturity are known as European options. Call option & Put Option can both be bought or sold by a trader. Party who longs call buy the right to buy the asset at a certain price at a certain time in future.

The person who owns an options contract can buy or sell the underlying object at a set price (the striking price) on or before the expiration date, but they don't have to.

Let's talk about what makes up an options deal.

1. **Underlying Asset:** The underlying asset is the financial object that the options contract is based on. It could have stocks, ETFs, commodities, or currencies in it. Indices like the Nifty 50 and the Sensex, as well as individual stocks like Reliance Industries and TATA Motors, are often used as underlying assets for options trading in India.
2. **Call and Put Options:** There are two main types of options contracts: call options and put options.

(a) **Call Option:** A person who owns a call option has the right to buy the underlying object at the strike price on or before the expiration date. If the price of the underlying product goes above the strike price, the person who owns the call option can go ahead and buy it at a lower price.

(b) **Put Option:** A person who owns a put option has the right to sell the underlying asset at the strike price on or before the end date. If the price of the underlying product falls below the strike price, the person who owns the put option can sell it at a higher price.

(c) **Strike Price:** The striking price, which is also called the exercise price, is the set price at which an option buyer can buy or sell the underlying commodity. If the person who owns the option thinks it will be profitable, this is the price at which it will be used. In Indian markets, strike prices are often set ahead of time based on how much the main asset is worth.

(d) **Expiration Date:** The date the option deal ends is either the day before or the day of. After the expiration date, the option is worthless and the user can't use it anymore. In India, options contracts usually expire once a month. Stock options expire on the last Thursday of the month, and index options expire on the last Thursday of the week.

For example, let's say you want to trade Nifty 50 index options. The Nifty 50 is trading at 19500 points right now, and you think it will go up soon.

For your call option buy, you choose the following:

- The Nifty 50 index is the underlying asset.
- Price to strike: 19,700 points
- It will run out on July 24, 2023.

You legally have the right to buy the Nifty 50 index at that price because you bought a call option with a strike price of 19500 points. If you use your call option to buy the Nifty 50 index at a lower price before it ends on June 24, 2023, you might make money if the index goes up more than 15,200 points by that date.

Let's understand with another example of gold trader. Let's suppose the gold trader would need 100 pounds of gold in September. Instead of going

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for Gold forward to lock the price gold trader buys September gold option contract with an exercise price of Rs. 7000 per gram. In September, if the gold price is more than 7000, trader will exercise contract to buy at exercise price but if it is less than 7000, trader will not exercise the contract and let it lapse as trader can buy gold from cash market at a lower price. The option contract provides trader to mitigate risk without foregoing potential to make profit from favourable price changes.

1.5.4 *Swaps*

Financial swaps are agreements between two parties to trade cash flows or debts based on certain financial assets or indexes. Swap goods come in many forms, such as currency swaps, interest rate swaps, equity swaps, credit default swaps, commodity swaps, and more. Over-the-counter (OTC) traders buy and sell swaps. They are flexible contracts. Let's talk about some types of swaps and how they work in the context of Indian financial markets.

Interest rates Swaps are swaps where two parties trade payments with both fixed and variable interest rates. One party to this swap agrees to a floating interest rate that is based on a reference rate, like the MIBOR (Mumbai Interbank Offered Rate). The another party agrees to a set interest rate. Interest rate swaps are a way to manage interest rate risk and get the cash flow you want. Example: An Indian company has a loan with a variable interest rate that it wants to lock in order to protect itself from future interest rate hikes. Someone who is ready to pay the set rate and get the variable rate could agree to a swap with the company. By doing this, the company may be able to switch its loan from one with an adjustable rate to one with a set rate, which will make its interest payments more stable.

In **Currency Swaps** one trade principal and interest payments that are written in different currencies. These swaps can help businesses that deal with foreign currencies and want to lower their exchange rate risk or get money in a different currency. When people trade currencies, they can take advantage of the differences in interest rates between countries. Let's understand with an example: An Indian company wants to expand its operations in the US and needs USD to do so. Indian Rupees (INR), on the other hand, make up most of its gains. To lower the risk of the

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exchange rate going up or down, the business can trade currencies with someone who wants INR and is willing to lend USD. Thanks to this trade, the company can now take loans in USD and pay interest and principal on a regular basis in INR.

Credit Default Swaps (CDS): Credit default swaps are contracts that let one party give credit risk to another party. One person or group gives another person or group a monthly fee in exchange for insurance against the failure of a certain financial instrument, like a bond or loan. CDSs are used to control credit risk or guess how creditworthy a provider will be. As an example: An Indian person who owns company bonds is worried about the issuer's creditworthiness. To protect themselves from the risk of failure, the investor can buy a credit default swap from another party. As long as the investor keeps making premium payments, the counterparty promises to pay back the investor if the issuer of the underlying bond fails.

Swaps give people in the market choices for managing their risk and being flexible. Companies can change how open they are to credit risks, currencies, and interest rates with these tools. But it's important to remember that swaps involve counterparty risk, and both sides should carefully check the creditworthiness of their partners before entering into swap agreements.

IN-TEXT QUESTIONS

2. Derivatives derive their value from which of the following?

(a) Underlying assets

(b) Counterparties

(c) Regulatory oversight

(d) Leverage

3. Which category of derivatives is often used for speculating or hedging with the goal of making money off of expected price changes?

(a) Futures contracts

(b) Options contracts

(c) Swaps

(d) Forward contracts

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4. Options contracts provide the holder the choice to do what?
   (a) Buy or sell an underlying asset
   (b) Exchange cash flows with another party
   (c) Purchase or sell a futures contract
   (d) Trade fixed and variable interest rate payments
5. Options contracts provide which of the following benefits?
   (a) Protection against downside risks
   (b) Limiting potential losses
   (c) Profiting from expected price changes
   (d) All of the above
6. Which exchange(s) in India are options traded on?
   (a) NSE (National Stock Exchange) only
   (b) BSE (Bombay Stock Exchange) only
   (c) Both NSE and BSE
   (d) None of the above

1.6 Participants of Derivative Market

The derivatives market have attracted many different types of traders and have a great deal of liquidity. When an investor wants to take one side of a contract, there is usually no problem in finding someone who is prepared to take the other side. There are mainly three categories of traders: Hedgers, Speculators & Arbitrageurs.

1. **Hedgers:** Hedgers are risk-averse market participants who use derivatives to manage or mitigate potential losses arising from price fluctuations in the underlying assets. Their primary goal is to protect their existing holdings from adverse market movements.
2. **Speculators:** Speculators are the risk-takers of the derivatives market. They enter into derivative contracts with the primary objective of profiting from price movements in the underlying asset. They attempt to anticipate future price movements and position themselves to benefit from them. A speculator who believes the price of the underlying asset will rise will buy a derivative contract. A speculator

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who believes the price of the underlying asset will fall will sell a derivative contract.

3. **Arbitrageurs:** Arbitrageurs are profit-seeking market participants who exploit price inefficiencies across different markets. They capitalize on minor price discrepancies between derivative contracts and the underlying assets in different markets to generate risk-free profits.
4. **Market Makers:** Market makers are intermediaries who provide liquidity to the derivatives market by continuously quoting bid and ask prices for derivative contracts. They ensure the smooth functioning of the market by facilitating transactions between buyers and sellers.
5. **Clearing Houses:** Clearing houses act as intermediaries that guarantee the settlement of derivatives contracts. They act as the central counterparty to all trades, ensuring that buyers meet their obligations and reducing counterparty risk in the market.

The interplay between these various participants is what drives the derivatives market. Hedgers and speculators provide the market with depth and liquidity, while arbitrageurs and market makers help ensure efficient price discovery. Clearing houses play a crucial role in managing risk and ensuring the stability of the derivatives market.

1.7 Summary

Financial tools called derivatives get their prices from changes in the prices of other assets. Traders use derivatives to bet on what they think will happen, protect themselves from risk, or arbitrage to take advantage of price differences in the market. A lot of people trade four main types of derivatives: futures, forwards, swaps, and options. Forward contracts are deals to buy or sell something at a certain time and price in the future. A spot deal, on the other hand, is an agreement to buy or sell an asset right away. On the over-the-counter market, forward contracts are bought and sold. Usually, they are between two banks or between a bank and a client. Two people agree to buy or sell something at a certain time and for a certain price in the future. This is called a future contract. Futures contracts are usually sold on an exchange, but forward contracts are not. Futures are traded on an exchange, and the exchange sets the base asset,

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the future price, and the date when the contract matures gives the owner the right to buy or sell an underlying object at a certain price and time in the future. A call option gives the holder the right to buy an underlying asset at a certain price at a certain time in the future. A put option, on the other hand, gives the holder the right to sell an underlying asset at a certain price at a certain time in the future.

Besides forwards, futures, options, bonds, and swaps, there are a number of other derivative products used in the financial markets. "Caps and floors" are types of derivatives that are used to trade or protect against changes in interest rates. Collateralized debt obligations and credit default swaps are two derivatives that can be used to reduce credit risk. Derivatives on commodities are financial tools used to manage price risk related to goods such as metals, oil, and natural gas. Special kinds of derivatives called "structured products" mix a lot of different instruments to make one-of-a-kind financial products. Mortgage-Backed Securities (MBS) are derivatives that make it look like you own a group of mortgage loans. Products that are traded on stock markets, like commodities, notes, and funds, are called Exchange-Traded Products (ETPs). Knowing everything there is to know about each derivative's features, risks, and goals is important before trading or investing.

1.8 Answers to In-Text Questions

1. *(a)* The maximum loss a trader is willing to incur
2. *(a)* Underlying assets
3. *(a)* Futures contracts
4. *(a)* Buy or sell an underlying asset
5. *(d)* All of the above
6. *(c)* Both NSE and BSE

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LESSON

2

Mechanics of Futures and Forward Markets

STRUCTURE

2.1 Learning Objectives

- Comprehending the detailed functioning of Futures Market.
- Understanding the theory of convergence of spot prices & future prices.
- Learning various characteristics of the futures market & future pricing techniques.

2.2 Introduction

As is well known, futures and forwards are financial agreements between two parties to purchase or sell an underlying asset at a specific price at a specific future date. Unlike forwards, futures are exchanged on an exchange. Because exchange-traded contracts are standardized, the exchange sets the underlying asset, amount, and maturity date. The supply and demand of the future contract decides the future price. Futures are long when parties agree to purchase the underlying asset, and they are short when parties agree to sell the underlying asset. Futures contracts are typically prefixed with the name of the month in which they will mature. For instance, 30 May Nifty Futures will expire on the 30th May of the year and the NIFTY index is its underlying asset. The majority of contracts settle on a cash basis when traders square off their positions prior to the delivery date rather than maturing by delivering the underlying. In order to square off a position, one must take a counter position; for example, in order to conclude a long futures deal, the trader must sell the same contract. Futures contracts are frequently used for hedging and speculation. The amount of money that must be deposited with the broker upfront in order to maintain a futures position is known as the margin requirement in futures trading. It serves as a good faith attempt to guarantee that the trader can fulfill their end of the bargain. In essence, it's a security deposit. Recall that futures contracts are leveraged instruments, which allows the trader to control a substantially higher contract value with a smaller initial investment.

2.3 Forwards Contract

A "forward" is a type of derivative contract that obligates the parties to buy or sell an asset at a defined price and on a specific future date. Let's examine the idea of forwards using examples. Assume that there are two entities involved: a company that processes food and a farmer. The farmer expects to harvest a large amount of flour in three months & the food processing industry needs a certain amount of wheat to meet its manufacturing needs. A forward agreement is signed by them. Contract terms are that over a three-month period, the farmer agrees to sell 10,000 bushels of flour to the food processing company for INR 1,000 per bushel.

On the specified date, which is three months following the contract's commencement date, both parties formally agree to fulfil their obligations under the forward contract.

Assume that, after a period of three months, the market value of a bushel of wheat has risen to INR 1,200. The food processing company benefits from the forward contract in this case because it may buy wheat for INR 1,000 per bushel, saving INR 200 per bushel over going market prices

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while farmer has to sell the flour at a price lower than market price as per forward contract.

Let's look at yet another illustration on forward Contract for Currency. Imagine that an Indian company has to purchase machinery from the US and needs to convert Indian Rupees (INR) to US Dollars (USD) in order to make the payment. To reduce the risk of currency fluctuations, company enters into a currency forward contract with a bank. Contract terms are that over the course of three months, company agrees to convert INR 10,000,000.00 into USD at the rate of one USD for every INR 70. After signing the currency forward contract, both parties commit to fulfilling their obligations three months following the date specified in the contract.

Assume that the exchange rate is presently 1 USD = 75 INR after three months. In this case, ABC Ltd. can purchase USD for INR 70 thanks to the forward contract, saving INR 5 per USD in comparison to the current exchange rate. Regardless of the condition of the market when the contracts expire, the parties to the forward contracts are in charge of fulfilling their obligations in both cases. Forwards are often customized contracts that are negotiated over-the-counter (OTC), as opposed to exchange-traded derivatives, which are standardized. Although they offer flexibility, they also subject the parties to counterparty risk because the contract is dependent on the linked counterparties' financial stability and trustworthiness.

Features of Forward Contract:

1. Bilateral in nature and thus subject to risk from opposing parties. Either of the two parties could fail to fulfil each of their responsibility.
2. Because it is customized, it is distinct in terms of quantity, quality, asset kind, and delivery date, among other factors.
3. By agreeing to purchase the good at a set price, one party assumes a long position, while the other party assumes a short position by agreeing to sell the good at the same price.
4. When the asset is delivered on the delivery date, the contract must be settled.
5. Forwards are illiquid in nature.
6. Forwards may not require any initial margin deposit to take exposure of the same.

2.4 Futures Contract

Futures are standardised derivative contracts that require the buyers and sellers of an underlying asset to transact at a pre-set price and date in the future. Futures are traded over exchange and exchange states the underlying, delivery, size of contract, minimum change in price. Let's examine the idea of futures using examples:

Illustration 1: Equity Index Futures

Shashi, an investor, wants to be exposed to the performance of the Nifty 50 index. He decides to long Nifty 50 Future contracts. One Nifty 50 futures contract with lot size of 75 units, which is equivalent to a specific amount of the Nifty 50 index depending upon ongoing future price, is bought by Shashi.

Outcome: Consider a scenario in which the Nifty 50 index has grown by 1000 points by the expiration date. Shashi's futures contract would have increased in value in this scenario, and he might sell the contract for a profit. The profit would be determined by the increase in future value multiplied by the volume of the contract.

If not sold before expiry, the contract gets cash settled and cease to exist automatically on the expiration. Index future contracts listed on Indian stock exchanges expires on the last Thursday of the expiry month.

Illustration 2: Commodity Futures

Kalyan Jewellers requires a particular amount of gold to satisfy its production demands. It chooses to employ commodities futures contracts as a hedge against the possibility of rising gold prices.

Contract Terms: A gold futures contract is bought for a specific amount of gold at an ongoing future price. Trading for the futures contract takes place on a commodities market, such as the Multi Commodity market (MCX). Kalyan Jewellers purchases the futures contract.

Outcome: Let's say gold is worth more on the market at the date of expiration. In this situation, Kalyan Jewellers may sell the futures contract in the market at higher amount & make profit. Kalyan Jewellers may buy gold in the cash market at an increased market price but effectively it bought for lesser price owing to the profit made on futures contract.

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Both examples use futures contracts, which are available to market participants since they are standardised and traded on established exchanges. They offer an easy approach for investors to diversify their exposure to other asset classes and give them the opportunity to bet on market movements, hedge against price volatility, or improve portfolio performance. When compared to over-the-counter (OTC) derivatives, futures contracts provide liquidity, transparency, and centralised clearing, lowering counterparty risk. Leverage is a component of futures trading that may compound gains and losses. Trading futures contracts requires rigorous risk management consideration as well as a full grasp of the underlying asset and market dynamics.

There are significant similarities between futures and forwards contracts, as both provide a way to lock price of underlying asset and mitigate market risk. A variety of underlying assets, such as commodities, currencies, stocks, interest rates, and more, can serve as the foundation for forwards and futures contracts. Both contracts frequently require an initial margin or collateral from both parties to ensure performance and lower counterparty risk. While there are some parallels between forwards and futures contracts, it's important to keep in mind that they also differ greatly from one another. The primary areas of variance are exchange trading, standardization, counterparty risk, liquidity, and flexibility which is available in a futures contract as opposed to a forward contract.

S.No.	Forward Contracts	Future Contracts
1.	These are tailormade contracts that may be adapted to each party's specific needs. The parties can determine their own delivery schedules and agreed upon quantities.	These are standardized contracts where exchange establishes contract details.
2.	Forwards are exchanged over-the-counter (OTC).	Futures contracts are exchanged on regulated markets, like stock exchanges or commodities exchanges.

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3.	Since forward contracts are established directly between the two parties, the counterparty risk is assumed by both parties.	Here exchange acts as the counterparty for both buyers and sellers, thereby there is no counterparty risk.
4.	Forwards contracts are illiquid. The party cannot wind up its position before expiry.	Futures contracts are more liquid as position can be liquidated as per the need of trader.
5.	Forward price discovery may be less transparent because each forward is independently negotiated and the outcome of talks between the parties.	Futures contracts provide transparent and easily accessible pricing information because they are exchange-based.
6.	These contracts may not be marked-to-market on daily basis & hence profits and losses are realized only when the contract expires.	Daily mark-to-market settlement applies to futures contracts, meaning that gains or losses are recorded daily based on how the contract's price moves. As a result, participants can easily move into or out of positions, reducing risk.

2.4.1 *Mechanics of Future Contracts*

Following are important characteristics of Futures:

1. **Standardization:** Futures contracts have a standard set of terms in addition to the contract size, delivery date, location, and other parameters like quality and number per lot. These conditions are established by the exchange on which the futures contract is traded.
2. **Pricing:** The futures price is set by the open market exchange between buyers and sellers. It is the market's estimate of what the underlying asset will be valued in the future, adjusted for supply and demand, interest rates, storage costs, and market mood.
3. **Trading:** Buyers and sellers can construct positions by buying or selling futures contracts on well-known platforms like the Multi Commodity Exchange (MCX) and the National Stock Exchange (NSE). By acting as a middleman, the exchange facilitates trade.

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4. **Margin Requirements:** Participants must first deposit margin money with their broker. The initial margin acts as security to guard against any losses. Participants may also be required to maintain a margin level as initial margin deposited depletes due to price movements.
5. **Mark-to-Market Settlement:** The underlying asset's price movement at the conclusion of each trading day is utilized to determine the contract's profits or losses. Any gains or losses are settled in cash, with the winning party receiving the difference from the losing side.
6. **Delivery:** Since cash settlement is used to settle most futures contracts, the underlying product is not delivered in person. Alternatively, if the contract is cancelled before the delivery date, the difference in price is settled in cash. Physical delivery is possible for certain contracts, such commodities futures, even if it is not particularly prevalent in practice.

2.4.2 *Role of Futures Exchanges and Clearing Houses*

Futures exchanges and clearinghouses are essential to the operation of futures trading because they provide a centralized market, mitigate the counterparty risk, and maintain market integrity. Exchanges are responsible for the following:-

- **Price Discovery:** By providing buyers and sellers with an efficient and transparent environment, exchanges facilitate an open and transparent process of price discovery. Futures pricing is influenced by supply and demand dynamics.
- **Standardization:** An open and transparent process of price discovery is achieved by providing buyers and sellers with a clear and efficient environment on exchanges. Futures pricing is influenced by supply and demand dynamics.
- **Market Access:** Exchanges provide access to a wide range of basic assets, including shares, currencies, commodities, and interest rates. This allows market participants to diversify their assets and increase their exposure to a wider range of sectors.
- **Regulatory Oversight:** Relevant organizations, like the Securities and Exchange Board of India (SEBI) in the case of Indian exchanges, are in charge of providing regulatory oversight for exchanges.

Regulatory oversight supports ethical trading practices, investor protection, and market integrity.

Clearinghouses act as an intermediary for buyers and sellers in the futures market. Among their responsibilities are:

- **Risk Management:** Clearinghouses lower counterparty risk by acting as the principal counterparty to all transactions. They guarantee that the vendor and the buyer fulfill their obligations. By reducing the default risk and offering performance guarantees, clearinghouses facilitate the smooth operation of the market.
- **Margin:** In order to participate, players must pay clearinghouses an initial and maintenance margin. While maintenance margin ensures that the margin account is sufficient, initial margin acts as collateral, shielding against any losses. Margin helps control risk and protects market participants from unfavourable swings in pricing.
- **Settlement:** Clearinghouses expedite the settlement process by setting the daily settlement price and guaranteeing the monetary payment of gains or losses. They calculate the net liabilities of each member and make the necessary financial transfers based on the findings.

2.4.3 *Factors Affecting Futures Contract Pricing*

Several factors that represent market dynamics and expectations for the underlying asset and the market at large have an impact on the price of futures contracts.

- **Spot Price of the Underlying Asset:** The asset's current market value, or the spot price, is a crucial aspect in establishing the futures price. The futures price usually has a close association with the spot price because market players employ arbitrage to cover any major price gaps between the two.
- **Cost of Carry:** This term refers to the expenses incurred in holding onto the underlying asset until the futures contract expires. It considers factors such as interest rates, financing costs, storage costs, insurance costs, and dividends (for equities). The carry cost affects futures prices; higher carrying costs result in higher futures prices.
- **Dynamics of Supply and Demand:** The underlying asset's supply and demand have a significant impact on futures pricing. If it is

projected that supply will decrease or demand for the asset will increase, futures prices may rise and vice versa.

- **Expectations and Market Sentiment:** The price of futures is impacted by investor expectations, the state of the market, and sentiment on the underlying asset. Depending on whether market participants think the asset's price will be trending positively or negatively, the futures price may fluctuate.
- **Time to Expiration:** A futures contract's price is determined by how much time remains until it expires. As the expiration date approaches, the futures price frequently converges towards the spot price, indicating a decreasing time value and reducing the likelihood of large price swings.
- **Interest Rates:** Interest rates affect futures prices, especially for financial futures contracts. When interest rates are higher, higher carry costs result in higher futures prices; conversely, lower interest rates have the opposite effect.
- **Volatility:** The pricing of futures is influenced by the price volatility of the underlying asset.
- **Market Liquidity:** The liquidity of the futures market itself may have an effect on pricing. Bid-ask spreads and price accuracy are generally tighter in high trade volume liquid marketplaces.

It's critical to keep in mind that these factors interact, and depending on the market and asset class, their effects on futures price may vary. Expectations in the market and unforeseen events can also impact pricing dynamics and heighten volatility.

2.5 Pricing of Futures

Spot price is the cost of asset that is available for delivery right now while future price is determined for transaction at future date. The financial cost, dividend, or interest attached to a financial asset is one of the main elements causing the difference between the current price and the future price.

Assume that Ravi has a share that he can sell for cash right now or later. If he sells the share right away, he can invest the money he received and get an interest on it, but he will also forfeit any dividends he might have received if he had held the share for a longer period.

Let's talk about another case now, in which Mr. B wishes to purchase a share. He has two options: he can buy a share right away at current market price or he can sign a future contract and receive the share later. If he enters into a future contract, there won't be a cash outflow right now, and he can gain interest on the purchase price, but he will also forfeit his dividend income as he is not holding shares anymore.

Consequently, the relationship between the spot and future prices can be written as:

$$\mathbf{F_o = S_o\ e^{rt}}$$

Where

F_o = Future Price

S_o = Spot Price

r = Risk-free interest rate

t = Period of investing

Let's investigate the several arbitrage opportunities that emerge when future pricing deviates from the previously established relationship with spot price. Take into consideration a long futures contract to buy a stock that doesn't pay dividends in three months. Assume that the 3-month risk-free interest rate is 4% annually and that the stock price is $50 at this time.

Assume $55 is the price in the future. An arbitrageur can purchase one share for $50 at a risk-free annual interest rate of 4%, purchase a future contract to sell one share in three months, and then sell the future contract. The arbitrageur delivers the share and gets paid $55 at the conclusion of the three months. $50.5 is the total amount needed to repay the loan. By the conclusion of the term, the arbitrageur has made a net profit of $4.5.

Let us next assume that the price in the future is $45. An arbitrageur can short one share, invest the money received at 4% annual interest rate for three months, and then buy a position in a contract that expires in three months. In three months, the short sale revenues increase to $50.50. The arbitrageur closes the short position by paying $45, accepting delivery of the share, and using it at the conclusion of the three-month period. At the conclusion of three months, there is a net gain of $50.50 - $45:- $5.50.

If "$F_o = S_o\ e^{rt}$" does not hold true, arbitrageurs can take counter positions in spot and future market which eventually will bring parity in prices.

Notes

When the underlying asset is an income yielding asset and absolute amount of income is known, in that case the price of future will reduce by the present value of income foregone due to deferring sale under future contract.

Price of Futures of Income Yielding Asset

$$F_o = (S_o - I)\ e^{rt}$$

Where

F_o = Future Price

S_o = Spot Price

r = Risk-free interest rate

t = Period of investing

I = Income Foregone (Interest or Dividend foregone)

Now, instead of focusing on known cash flow, we will examine the case where the asset that underpins a forward contract offers a known yield. As a proportion of the asset's price at the time the income is paid, this indicates that the income is known. That would entail giving up income yield if one owned future contracts. The lost income yield, or effective reduction in return, is what results from delaying payment under a forward contract.

$$F_o = S_o\ e^{(r-q)t}$$

Where

F_o = Future Price

S_o = Spot Price

r = Risk-free interest rate

t = Period of investing

q = Income yield

Let's take a numerical example on stock index futures pricing. Stock index futures are the future contracts on the stock market indices. It is a contract with specific terms to buy or sell the underlying stock index's face value. The difference between the index's value at the time of delivery and its initial purchase or sale is used to calculate the profit or loss from a futures contract that is settled at delivery. It's crucial to remember that in this case, delivery upon settlement must be in cash rather than the underlying shares.

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Assume that the Fin-Nifty index is at 20000 right now. The annual percentage rate of risk-free interest is 7%. The dividend yield every year is 2% on average. What will be the future price of the stock index after a year? Using the same formula as mentioned above:

Future Price = 20000 * $e^{(.07-.02)*1}$ = 21025

2.5.1 *Pricing of Commodity Future*

Contracts that deal with commodities as an underlying asset are known as commodity futures. Future commodity includes agricultural commodities like cattle, wheat, oil; metal commodity like crude oil, gasoline, silver, gold, copper, platinum, and so on.

Underlying asset of commodity futures are not dividend yielding asset but they carry storage & handling cost. Since the delivery will be picked up at a later time, the buyer of a commodity future saves money on storage because there are no storage costs. If "U" is the discounted present value of storage cost incurred, future price of a commodity future shall be modified as follows:

$$F_o = (S_o + U)\ e^{rt}$$

2.6 Convergence of Spot and Future Prices

A futures contract's price converges to the underlying asset's market price as the delivery time draws near. The futures price is equal to, or very near to, the spot price when the delivery term is reached. When the futures price is higher than the spot price during the delivery period, traders have a glaring chance for arbitrage:

1. Shorten or sell a futures contract
2. Purchase the item
3. Execute the delivery.

Proceeding in this manner will undoubtedly result in a profit equivalent to the difference between the futures price and the spot price. As traders take advantage of this arbitrage opportunity, the price of futures will decrease. Let us next assume that throughout the delivery period, the futures price is lower than the spot price. It will be appealing for businesses interested in purchasing the asset to sign a long futures contract

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and then wait for delivery. The price of futures will typically increase as they do this. As a result, during the delivery period, the futures price is quite close to the spot price. The convergence of the futures price to the spot price is depicted in Figure 2.1.

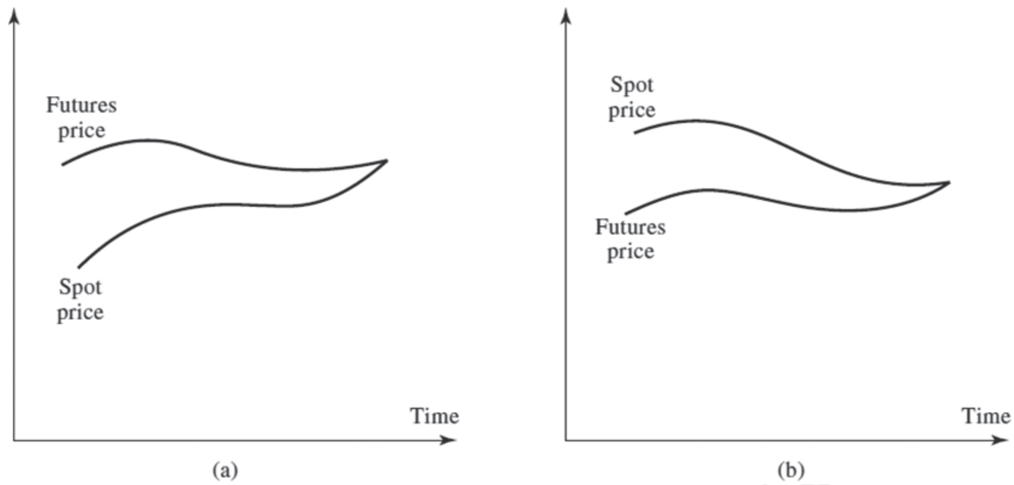

Figure 2.1: Convergence of Spot & Future Prices.

When the futures price is below the expected future spot price, the situation is known as normal **backwardation** as suggested in Figure 2.1(a); and when the futures price is above the expected future spot price as suggested in Figure 2.1(b), the situation is known as **contango**. However, it should be noted that sometimes these terms are used to refer to whether the futures price is below or above the current spot price, rather than the expected future spot price.

2.7 Hedging Strategies Using Futures

Contemporary business has progressed into a more complex and unpredictable environment. So, for the business to run properly, it is important for business leaders to deal with this kind of risk and doubt. Futures markets help managers lower or control their risk by sharing it to people who are willing to take it, like in the stock market. Another way to say this is that the managers might be able to lower and control their pricing risks by using certain forward market tools. Hedging is the act of protecting oneself against potential loss. In the context of futures trading, hedging is more precisely defined as the use of futures transactions to eliminate or decrease price risk in the spot market. Put differently, a hedge is a position that is taken on to safeguard the value of an existing position in an asset (or liability) until the position is liquidated, or to temporarily mitigate the unfavourable price movement on an asset. When you hedge, you try to lower the possible risks or unknowns that come with financial investments, deals, or other ventures. It means taking actions or positions that balance out the bad things that could happen because of changes in the market, prices, interest rates, or other things. When you trade futures with the goal of lowering or controlling risk, this is called hedging.

For instance: A cotton mill estimates that it would require 10,000 units of cotton by July 2024 in March 2024. Cotton currently costs \$1,000 per unit. To maintain stability and avoid a significant price increase beyond \$1000 per unit, the corporation buys 10,000 cotton units in the futures market, where the going rate is \$1050 per unit. July brings with it a sharp increase in cotton prices, with spot prices hitting \$1500 a unit. Cotton for July has a going futures price of \$1498 per unit. The cotton mill now has two options: One is that it can sell its futures contracts at the going rate of 1470 and buy required cotton from market at spot prices. The profit profile of the transaction will be equal to 1498 – 1050 = 448 per cotton unit and hence, effective buy price per unit of cotton = 1500 – 448 = Rs. 1052 per unit. Another option is that cotton might be purchased directly by the mill from the futures market. The mill would pay \$1050 in this case for each unit, but there's a danger that when it comes to accepting delivery, the same kind of cotton might not be provided. The example illustrates how the company has hedged against the risk of increasing prices by acquiring futures. Taking a position in futures that is the opposite of one's position in the cash market to mitigate expected unfavourable price movement is hedging via futures.

Short Hedge: Short hedging is taking a short position in a futures contract to mitigate market risk on existing long position in underlying asset in spot market or imminent position. In other words, it occurs when a business or trader sells futures to hedge against their cash position when they plan to purchase or produce a commodity with cash. Therefore, protecting against a decline in cash prices while preserving the value of the cash position is the major objective in this scenario. A short hedge is appropriate when the hedger already owns underlying asset and plans to sell it in the future. Once the short futures position is opened, the

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expectation is that any change in the cash position's value will be more than compensated for by a gain (loss) on the short futures position.

Let's say an American exporter who knows that in three months a German company will pay him Euros. The exporter will make money if the mark appreciates in value relative to the US dollar; if not, the exporter will lose money. By taking short position in Euros Futures contract maturing in 3 months, exporter can fix the selling price in advance. As the Euro's value increases, a short futures position results in a loss but exporter can sell Euros at higher price in cash Euro set while if it decreases, a short futures position results in a gain but exporter can sell Euros at lower price in cash Euro set a gain. The example is further elaborated below:

Spot Market	Futures Market
June 10 In three months, anticipate to sell 100000 Euros and receive $1.5 per Euro, or $ 150000 for the entire contract.	**June 10** Sell 100000 Euros via futures contracts for delivery in August at $1.5 per Euro.
August 10 Euro current spot price is $1.45 per Euro and the exporter sells 100000Euro for $1,45,000 for the entire contract. Earnings = $ 145000	**August 10** Purchases Euro futures contract for $1.45, Futures Profit= $ 5000

Example elucidates that exporter mitigated the downside risk and locked price on Euro by hedging short on futures contract.

Long Hedge: Long hedges are those that entail taking a long position in a futures contract. If a business wants to lock in a price today and knows it will need to buy a specific asset in the future, it should consider a long hedge.

Let's say it is 10th January 2024 and an aluminium fabricator is aware that in order to fulfill a contract, 100,000 pounds of aluminium must be received by May 15. Aluminum is currently trading at Rs 3400 per pound on the spot Market, while the May delivery futures price is Rs. 3200 per pound. The MCX offers four futures contracts that the fabricator can take a long position in to hedge its position. The transaction must be closed by May 15th. The delivery of 25,000 pounds of aluminium is the subject of each contract. This has the effect of fixing the needed aluminuim price at about Rs. 3200 per pound.

Assume that on May 15, the spot price of aluminium is Rs. 3250 per pound. This should be extremely close to the futures price because May is the contract's delivery month. As a result, the fabricator makes about Rs. 50,00,000. It purchases the aluminium for 100,000 * 3250 i.e. Rs. 3,250,00,000, therefore, the net cost comes to about Rs. 3,250,00,000 – Rs. 50,00,000 = Rs. 3,200,00,000. As an alternate scenario, let's say that on May 15, the spot price is Rs. 3050 a pound. After that, the fabricator pays Rs. 305,000000 for the aluminium and loses around Rs.15,000000 on the futures contract. Once more, the net price comes to almost Rs. 3,200,00,000 or Rs. 320 cents per pound.

Keep in mind that using futures contracts in this instance is unquestionably preferable for the corporation than purchasing the aluminium on January 15 on the open Market. If it chooses the latter, interest and storage fees will be incurred in addition to paying Rs. 340 per pound as opposed to 320 cents. The ease of having aluminum on hand might outweigh this drawback for a business that uses it frequently. That being said, a corporation that knows it won't need the aluminium until May 15 is probably going to favor the futures contract alternative.

Cross Hedging: All of the aforementioned hedging positions include futures contracts on the same assets whose prices will be hedged; these contracts expire on the same day as the hedging is to be closed. There are times when businesses want to protect themselves against a certain product but there are no futures contracts available. This kind of situation is called "asset mismatch." Further a maturity mismatch is when the same futures term (maturity) on a certain product is often not available. One can still protect against such price risk by using futures contracts on related assets that expire at different times than when the hedge position is to be closed and this is known as Cross Hedging. It won't happen very often that everything works out so well in real life and in the economy. This is why Cross hedge is different from a straight hedge because the spot and futures contracts don't exactly converge.

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Cross Hedging is carried out when:

- The end date of the hedge may not be the same as the expiration date of the futures contract.
- It's possible that the amount that needs to be hedged is different from the amount of the futures contract.
- It's also possible that the asset that needs to be hedged is not the same as the asset that was used in the futures contract.

There will always be some risk unmitigated in cross hedging. We need to identify futures contracts that would work well for a cross hedge. For example, if we want to protect our silver coin collection, a silver futures contract would work better than a gold futures contract as a cross-hedge. If the correlation between prices of underlying asset and the asset that needs to be hedged is almost perfect, cross-hedging is effective. And if the correlation is negatively perfect, there will be no hedging; holding a position in the futures will raise risk.

Hedge Ratio: A "hedge ratio" compares the total value of a position to the value of each hedged position; it's a computation that takes both into account. To find a hedge ratio, you compare the value of the cash product that is being hedged to the value of any futures contracts that are bought or sold.

Traders can lock in a price for a real good at a later date with futures contracts. In order to fully hedge an open position, the hedge ratio must be 1, or 100%. On the other hand, if the hedge ratio is zero, or 0%, it means that the open account has not been hedged at all. For effective risk management, you need to know your hedge ratio. This number tells you how much your hedging instrument will move to balance out changes in the value of your assets or loans.

Let's now look at the optimal hedge ratio, which is also called the minimum-variance hedge ratio. Optimal hedge ratio is a risk management ratio that tells how much of the portfolio one should hedge. The optimal hedge ratio may be computed as:

$$\mathbf{h = \rho \ x \ (\sigma s \ / \ \sigma f)}$$

This number, ρ, shows how closely changes in your future price are linked to changes in the market price right now.

σs = Standard Deviation in spot price of Asset to be hedged

σf = Standard Deviation in future price

Illustration:

A business knows that it needs to buy 20,000 barrels of palm oil sometime in November or December. It is June 26. Presently, oil futures contracts are bought and sold on the MCX every month for delivery. The amount of the deal is 1,000 barrels. So, the company decides to hedge its risks with the December contract and buys 20 December futures at a higher price. Future price of oil is $88.00 per barrel on June 8. The business learns that it is ready to buy the oil on November 10. As a result, its futures deal ends on that date. On November 10, the cash price is $91 per barrel and the futures price is $89.10 per barrel.

The gain on future contract is 89.10 – 88 = $1.10 per barrel.

Basis = 91 – 89.10 = 1.90 per barrel

Effective price of coal = Spot price – gain on future contract = 91 – 1.10 = 89.90 per barrel

Price can also be computed as Exercise price of future contract + Basis = 88 + 1.9 = 89.90 per barrel.

Illustration:

A stockholder owns fifty thousand shares as of July 1. Each share costs $30 on the market. The individual wants to protect themselves against changes in the market over the next month, so they choose to use the September Mini S&P 500 futures contract. Right now, the price of an index futures contract is $1,500, and one contract is for delivery of $50 times the index. The stock has a beta of 1.3. What strategy should the owner follow?

Current value of portfolio = 30 * 50000 = Rs. 1500000

Number of Mini S&P 500 future contract trader must short = (Beta * value of portfolio)/ Value of future Contract

= (1.3 * 1500000) /1500 * 50

= 1950000/75000 = 26

To hedge against market price movement, trader must short 26 November Mini S&P 500 future contracts.

Notes

IN-TEXT QUESTIONS

1. Contango is a market condition for a given underlying in which

(a) Spot price is bigger than Futures price

(b) Spot price is smaller than Futures price

(c) Near Futures price is bigger than distant Futures price

(d) None of the above

2. A trader booked one-month forward contract on February 24th (Friday). Its delivery date will be

(a) March 24th

(b) March 26th

(c) March 28th

(d) March 31st

3. Theoretical Price of futures is:

(a) Spot Price + Cost to carry

(b) Spot price + cost to carry + convenience yield

(c) Spot price + cost to carry - convenience yield

(d) None of the above

4. A short hedge is an appropriate hedge for

(a) Importer *(b)* Exporter

(c) Both *(d)* Arbitrageur

5. Which of the following statement (s) is/are true as eligibility for inclusion of securities in F&O segment?

(a) The stocks would be chosen from amongst the top 500 stocks in terms of average daily market capitalization

(b) For a stock to be eligible, the median quarter sigma order size over the last six months should not be less than Rs. 25 lakh.

(c) The Market Wide Position Limit in the stock shall not be less than Rs 500 cr.

(d) All of the above

2.8 Summary

The forward Market is a global Marketplace that was established initially to facilitate the buying and selling of commodities by farmers and merchants for immediate or future delivery. Due to their bilateral nature, forward contracts are susceptible to counterparty risk. Every day, futures accounts that are traded on exchange, are settled, either credited or debited, based on the profits or losses realized.

Hedging is a way to protect yourself from losing money in the future that you can't predict. A long hedge means buying futures and selling them short, while a short hedge means selling futures and buying them short. When picking a hedge plan, basis risk is one of the most important things to think about. If you want to lower your risk when the value of your total position changes, you should swap a certain number of shares for one call or put. This is called the hedge ratio. It also shows the percentage of holdings in the futures market compared to the cash market. Three parts of hedging management are keeping an eye on, making changes to, and reviewing a hedging plan.

2.9 Answers to In-Text Questions

1. *(b)* Spot price is smaller than Futures price
2. *(d)* March 31st
3. *(b)* Spot price+ cost to carry + convenience yield
4. *(b)* Exporter
5. *(d)* All of the above

2.10 Self-Assessment Questions

1. Gold dealer needs 100 kg of gold by December 20 to fulfil a specific contract. The current price of gold is Rs. 5000 per gm, while the price of gold in the futures market is Rs. 5200 per 1 gm. Each contract traded on NCDEX has a weight of 10 kg. Which form of position in the futures market should the gold trader take?
2. The beta of a company's $20 million portfolio is 1.2. It wants to lower its risk by buying futures options on a stock index. At the moment, the price of an index futures contract is $1080, and each

Notes

contract is for delivery of $250 times the index. What is the hedge that lessens risk? In order to get the portfolio's beta down to 0.6, what should the company do?

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UNIT - II

L E S S O N

3

Currency Futures

STRUCTURE

3.1 Learning Objectives

- Comprehending the detailed functioning of Currency Futures Market.
- Understanding the basis risk.
- Learning strategies for hedging foreign exchange risk.

3.2 Introduction

Every country has its own currency, which is influenced by many factors, such as the macroeconomic dynamics, the actions taken by the central bank, the amount of demand and supply, the amount of foreign exchange reserves, geo-political dynamics etc. Value of the currency of one country changes all the time compared to the currency of another country. The exchange rate between two different currencies is called the foreign exchange rate. It shows how much one country's currency is worth in terms of another country's currency. In other words, the foreign exchange rate is the amount of local currency that is needed to

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buy one unit of foreign currency. One American dollar can be traded for eighty Indian rupees, for example. So ₹80/$ will be called the "$ exchange rate in terms of ₹." The exchange rate directly affects how much money is paid for imports and how much money is earned from exports.

Currency forwards and futures are derivative instruments with foreign currencies as the underlying asset. Foreign currencies as an asset is considered to be an interest yielding asset as one can invest in foreign currency denominated securities issued by treasuries and earn a risk-free rate of return. Currency derivatives let people in the market trade and bet on the exchange rates between different currencies. Contracts for derivatives are based on common currency pairs, such as one can buy and sell USD/INR, EUR/INR, and GBP/INR.

People use these tools to protect themselves from changes in the exchange rate. Usually, investors who need foreign cash in the future but don't want to buy it right now can buy currency futures or forwards. This purchase protects the buyer against foreign currency exchange rates. Forex futures are another name for currency futures. Currency futures are exchange traded instruments while forwards are counterparty agreements.

3.3 Direct and Indirect Quotation

Quotes for exchange rates are usually given in currency pairs. Currency pairs are traded on foreign exchange markets for example, USD/EUR; USD/INR; GBP/EUR; JPY/USD are currency pair. If j/k is a currency pair j^{th} currency is base currency and k^{th} currency is the quote currency.

For example, if USD/INR is 80, it implies that 1 $ is being traded at Rs.80 as $ is the base unit and Rs. Is quote currency.

Exchange rates can either be quoted in direct terms or indirect terms.

It is called a "direct quotation" if an exchange rate quote shows how much quoted domestic currency is worth for each unit of quoted foreign currency i.e. domestic currency per unit of foreign currency. On the other hand, exchange rates that are given as the number of units of foreign currency for each unit of domestic currency are called indirect quotes. Foreign currency per unit of domestic currency is known as indirect quotation JPY/INR is direct quote of JPY while INR/JPY is an indirect quotation.

Bid and Ask Quotations are the prices at which dealer is willing to buy and sell the foreign currency respectively. The difference between ask and bid price is known as spread earned by dealer for assuming operational and market risk. The relation between bid & ask quotation of a currency pair is depicted as follows:

$$S^a\ (\$/£) = 1/\ S^b\ (£/\$)$$

Illustration 1:

Let's say a tourist from the United States wants to buy Japanese yen at XYZ Airport. The dealer is ready to buy one USD for JPY 110.34 (bid) and sell one USD for JPY 111.09 (ask). Every time the dealer buys and sells a USD, she gains JPY.75.

If the quotation for JPY/USD is 1.25, with a bid price of 1.24 and an ask price of 1.26. Calculate the bid and ask rates for USD/JPY.

Solution:

Given: Indirect Quotation: JPY/USD = 1.25; Bid Price: 1.24 (JPY/USD); Ask Price: 1.26 (JPY/USD)

To find the direct quotations for USD/JPY: Bid Rate (USD/JPY) = 1/ Ask Price (JPY/USD)

Bid Rate (USD/JPY) = 1/1.26 ≈ 0.7937

Ask Rate (USD/JPY) = 1/Bid Price (JPY/USD)

Ask Rate (USD/JPY) = 1/1.24 ≈ 0.8065

Therefore, the bid rate for USD/JPY is approximately 0.7937, and the ask rate for USD/JPY is approximately 0.8065.

3.4 Cross-Currency Rates

Cross-currency rates show how much one currency is worth in another currency that is not the official currency of the place where the rate is given. To put it more simply, it's the exchange rate between one currency and another currency that isn't the home currency. Banks handle currency against currency trades, such as for the bank customer who wants to trade out of one foreign currency like British pounds and trade into another foreign currency say Swiss francs, at the cross-rate desk. Let's look at a numerical illustration.

Notes

Illustration 2:

If JPY/CAD is 1.25 and USD/CAD is 50, the quotation for JPY/USD can be computed as:

(JPY/CAD) * 1/(USD/CAD) = 1.25 * (1/50) = 0.025 JPY/USD

Cross-currency rates are used to determine rate of foreign currencies and help in bringing parity between market rates. People who deal with foreign money often use cross-currency rates, especially when it's not possible or common to exchange two currencies directly. These rates are very important for companies and investors who do business and invest around the world. Cross-Currency rate can be determined using Bid Ask prices as follows:

Let's assume Swiss franc and Pounds are foreign currencies and $ is the domestic currency. The currency (say S j/k) superscripted with "b" is bid rate of j in terms of k while the one superscripted with a is the ask rate of jth currency in terms of k.

So bid & ask currency rate for Pounds in terms of Swiss francs will be computed as follows:

$$S^b(SF/£) = S^b(\$/£) * S^b(SF/\$)$$

If reciprocated on either side:

$$S^a(£/SF) = S^a(£/\$) * S^a(\$/SF)$$

Illustration 3:

The following are the exchange rates that a bank is giving for the Australian dollar and the Swiss franc against the Canadian Dollar:

SF/CAD = 1.5960 – 70

A$/CAD = 1.7225 – 35

What rate would the bank give for A$/SF?

Since S^b(A$/SF) = S^b (A$/CAD) * S^b (CAD/SF) = 1.7225 * 1/ S^a (SF/CAD)

= 1.7225 * 1/ 1.5970 = 1.0785

Also S^a(A$/SF) = S^a(A$/CAD) * S^a (CAD/SF) = 1.7235 * 1/ S^b (SF/CAD)

= 1.7235 * 1/ 1.5960 = 1.0798

So quotation for A$/SF will be 1.0785-98.

3.5 Currency Forwards & Currency Futures

There is both a spot market and a forward market for foreign exchange. When you trade on the forward market, you agree to buy or sell foreign exchange in the future. Spot and forward prices don't always match up as currency may be selling at a premium or discount to spot price. Rates of forward exchange are listed on most of the world's major currencies for a range of maturity dates. It's easy to get prices from banks for terms of 1, 3, 6, 9, and 12 months.

Currency futures are standard contracts that can be bought or sold on a market to buy or sell a certain amount of a currency at a certain price on a certain date in the future. Traders can use these contracts to protect themselves against changes in currency exchange rates or bet on them.

Some important characteristics about currency futures are:

- **Standardization:** The size, expiry date, and settlement terms of currency futures contracts are all the same. Standardization makes it easy to trade on organized markets like the Intercontinental Exchange (ICE) or the Chicago Mercantile Exchange (CME).
- **Size of Contract:** Each currency futures contract is worth a set amount of the currency that it is based on. A standard EUR/USD futures contract might be worth 125,000 euros, as an example.
- **Date of Expiration:** Currency futures contracts have a set date when they expire, which is usually the third Wednesday of some months. After this date, the contract is settled, either by delivering the money in person or by paying the agreed-upon amount in cash.
- **Settlement:** There are two ways to settle currency futures contracts:
- **Physical Delivery:** On the date of expiration, the buyer and seller trade the underlying currency at a rate that has already been agreed upon. There is a cash settlement for this contract based on the difference between the contract price and the spot exchange rate on the date it expires.
- **Margin Requirements:** In order to trade foreign futures, traders must put down an initial margin and keep a minimum maintenance margin. The amount of margin needed depends on things like the size of the contract and how volatile it is.

Notes

- **Leverage:** Because of leverage requirements, currency futures traders can control a lot of currency with a small beginning investment. This leverage makes both gains and losses bigger.
- **Liquidity and Transparency:** The currency futures market is very liquid, which means that traders can easily join and leave positions at prices that are competitive. Additionally, exchange-traded futures make prices and market depth clear.

3.5.1 *Pricing of Currency Futures*

Currency as an underlying asset is an income generating one as one can invest in foreign currency denominated securities issued by treasuries and earn a risk-free rate of return. Here, r_f is the value of the risk-free interest rate for a given amount of time T.

To derive the price of currency future let's assume that trader holds 1000 units of foreign currency at time T. Trader has two avenues of converting it into domestic currency: One to convert into domestic currency immediately in the cash mark and earn domestic return on the same. The proceeds in that case will equal 1000 $*S_o e^{rt}$.

Second alternative is to remain invested in foreign currency for time period and concurrently sell investment proceeds in futures markets at ongoing future price (say F_o). Proceeds in this case will be $1000*F_o e^{rf*t}$ where r_f is risk-less return on foreign currency denominated security.

When there is no arbitrage possibilities i.e. when markets are efficient:

$$F_o e^{rf*t} = S_o e^{rt}$$

$$F_o = S_o e^{(r- rf)t}$$

3.6 Hedging Using Currency Futures

Businesses and investors can protect themselves from possible losses and lower the risk of unfavourable currency movements by using currency futures as a hedge. But it's important to think carefully about things like transaction costs, margin requirements, and how well the hedge plan works at reducing currency risk. Hedging tactics can also be put into action more effectively by getting advice from financial experts or people who work with foreign exchange markets.

Let us look at the case of a US seller who knows he will get euros in three months. If the value of the euro rises against the US dollar, the seller will make more in terms of $ and will make lesser if the value of the euro goes down against the US dollar. Suppose seller takes a short futures position, he will lose money in the contract if the value of the euro goes up and make money if it goes down. In this case, the counter position in futures contract helps seller offset losses against profit and reduce risk.

To hedge against exchange rate movement one need to figure out how much foreign exchange risk one's business or trading portfolio is exposed to. This could include the risk of changes in exchange rates when importing, exporting, investing, or doing other business with foreign currencies.

Select Currency Futures Contract: Pick the currency futures contract that makes sense for the currency you are exposed to. As an example, you would choose a euro futures contract if you have risk with the Euro.

Find the Hedge Ratio: To find the hedge ratio, divide the value of the currency futures contract by the value of the risk that it protects. This helps you figure out how many futures contracts you need to properly protect yourself from risk.

Enter Hedge Position: You can enter a currency futures contract by either buying or selling futures contracts, based on whether you want to protect yourself against the currency going up or down in value. You would sell futures contracts to lock in the current exchange rate if you think the foreign currency will go up in value. To set a firm exchange rate, you would buy futures contracts if you think the value of the foreign currency will go down.

Settlement: When the futures contract's term ends, settle it by either sending or getting cash payments equal to the difference between the price of the futures contract and the spot exchange rate at that time.

3.6.1 *Basis Risk*

The basis is the difference between how much the spot price is worth and how much the future price is worth. It is the possible risk that an investment trader would take by taking the opposite stake in a derivative category, which could be the forward or future of the underlying asset. If the underlying and asset to be hedged is identical, then the basis risk is zero at the time of expiry but the future price and spot price may be

Notes

different before expiry. The spot price and the futures price for a certain month don't always change by the same amount over time.

b(t)T = S(t) – F(t)A, where b is the reason

S = Price at the spot

F = Price in the future

T = Period of Maturity

t = certain date

Let's assume that a hedging position is taken at time t1 and liquidated at time t2. Currency futures are short at F1. Now at time t2 when position is squared off in futures market, trader gains by F1 – F2 while currency is sold for S2 i.e. Effective selling price for trader "S2 + F1 – F2" since F1 was known when position was taken so only uncertain part of equation is the basis risk i.e. S2 – F2. If S2 equates F2 when position is closed out and cash market transaction is made, S2 – F2 is zero i.e. basis risk is zero but either due to different underlying asset or mismatch in maturity and cash market transaction there may be a difference between spot and future price at which position is squared off. This risk is known as basis risk.

Basis risk affect the hedging position. Think about a business that uses a short hedge because it wants to sell the underlying foreign currency. If the basis unexpectedly strengthens, the company will be in a better situation because it will be able to sell the foreign currency for more money after futures gains or Losses are taken into account; if the basis weakens (i.e., falls) without warning, the company's situation gets worse.

Different kinds of Base Risk

1. **Price Basis Risk:** This is the risk that comes up when the prices of an asset and a future asset don't move in sync with each other.
2. **Location Basis Risk:** This is the risk that comes up because the core asset and its future contracts are in different places. For instance, the basis for petrol sold in Delhi and petrol futures traded on a futures market in New York might be different from the basis for petrol and petrol futures traded in Delhi.
3. **Base Risk for Product Quality:** The basis will be different if there is a quality difference between the base asset and the asset that is represented by a future contract.

3.6.2 *Early Delivery, Extension or Cancellation of Currency Forward Contracts*

As a forward contract is an agreement to swap currencies at a later date, it is possible that the customer will not be able to keep to the agreed upon delivery date or that the transaction itself will be changed or canceled. In these situations, the buyer or exporter may ask for early deliver, extension or cancellation.

The customer can ask the bank to cancel the forward contract if the underlying deal goes wrong or if he wants to avoid it for any other reason. If the actual transaction is going to happen on a day after the due date of the forward contract that was already booked, he may ask for the due date of the contract to be pushed back. If the customer wants to stop or extend the forward contract, they can do so at any time before or after the due date.

Cancellation of Currency Forward Contracts

In a forward contract, the customer can back out at any time while the contract is still valid. If one wants to cancel, one must follow Rule 8 of the FEDAI. Cancellation of forward can be executed by taking counter position. The gap between the agreed-upon rate and the rate at which the cancellation takes place must be paid back to the customer, if the customer asks for the cancellation. When the forward contract is canceled on the due date, the spot rate is to be used. The customer is responsible for paying the cancellation fees, and they don't get any of the profit since the loss was their fault.

Let's look at an example: Say an Indian trader bought 25000 Swiss francs on March 15th, from the forward market and agreed to receive them on April 15th at a price of Rs. 7.04. On the due date, the customer asks to get out of the deal.

On 15th April

Spot: 1 USD = 6.0200/0300 SF

One month 305/325

Two months 710/760

Here is how much the U.S. dollar was worth on the local interbank exchange market on the date of closure.

Notes

One US dollar is equal to INR 42.2477/2975

Spot/May 3000/3100

Spot/June 6000/6100

How much will the customer have to pay to cancel?

So, the sale agreement will be broken at the ready T.T. buying rate. The exchange rate between dollars and rupees is Rs. 42.2477.

Dollar/Swiss Franc market spot dealer selling rate of FRF 6.0300, and Dealer buying rate for Franc in terms of INR = S^b INR/SF = S^b INR/$* S^b $/SF

= (S^b INR/$)/$S^a$ SF/$

= (42.2477/6.0300)

= Rs. 7.0062.

Since the Swiss franc was sold to the customer for Rs. 7.0450 and is now being bought from him for Rs. 7.0062, the net amount the customer owes for each franc is Rs. 7.0450 – Rs. 7.0062 = 0.0388 per SF

Total payable by customer is equal to 0.388 * 25000 + 100 (flat cancellation fee applicable)

Extension of Currency Forwards

An exporter finds that he can't send his goods out on time, but he plans to do so in about two months. The supplier can't pay on time but is sure they'll be able to pay a month later. In both of these situations, they can go to the bank they have an account with and get their respective forward contracts due date postponed. When the date of delivery under a forward contract is pushed back, this is called an extension of forward contract.

In the past, it was common to extend the contract at the same rate that was first offered to the customer and then charge the customer extra for the increase. Once a forward contract is extended, the reserve bank has stated that it must be canceled and rebooked for the new delivery time at the current exchange rates. This rule takes effect on January 16, 1995. It has been made clear by FEDAI that exchange reserves do not need to be loaded when forwards contracts are both canceled and rebooked at the same time. But it has been seen that banks do include a margin for withdrawal and rebooking, just like they would in any other case. Also, only a flat fee of Rs.100 (at least) should be charged, not Rs. 250 like when a new contract is booked. Extension may be informed on maturity date or before maturity date. The position that an importer or exporter needs to take in each case is stated below.

	Date of Delivery	**Before Date of Delivery**
Importer	Swap Out	Fwd-Fwd-Out
Exporter	Swap In	Fwd-Fwd In

Where

Swap In is When long position is taken in the spot market and short position is taken in the forward market

Swap Out: When short position in spot market and long position in forward market

Forward-Forward-In: When long position is taken in near forward and short position in distant forward

Forward-Forward Out: When short position in near forward and long position in distant forward

Let's take a numerical example: An Indian importer has a payable of Rs. 5,00,000 due on 31 December 2023.

On 1 October 2023, importer cover payable by taking long forward position at Rs. 80.34 from banker. On 31/12/2023, he requests to extend contract till 31/1/2024.

On 31/12/2023

Spot INR/USD 80.54/63

1 month forward 80.56/68

What will be importer's cash flow position.

So on 1/10/2023, Bank must have taken an interbank position of buying 500000 USD forward so that it can assure delivery to importer.

When extension is sought, bank has to close Interbank position by taking USD delivery and sell it in spot market at INR 80.54

Bank shall also book another 1-month forward contract on USD in Interbank market at INR 80.68.

The gain or loss incurred to bank owing to selling in spot market and buying in forward will belong to or will be borne by importer.

Notes

In this case gain is accrued on selling USD

(80.54 – 80.34)* 500000

= 100000

On 31/1/2024

Cash outflow of Importer = 80.68 * 500000 – 100000 (gain) = 4,02,40,000

IN-TEXT QUESTIONS

1. Which of the following may be participants in the foreign exchange markets?

(a) Bank and non-bank foreign exchange dealers

(b) Central banks and treasuries

(c) Speculators and arbitragers

(d) All of the above

2. When an importer request for extension of forward contract then counterparty may have to go for:

(a) Swap in transaction

(b) Swap out transaction

(c) Both *(a)* and *(b)*

(d) None of the above

3. Ms. Saanvi who is working at California, transferred $10k to her parents in Delhi. How much money will be realized by her parents if the prevailing spot rate is $/Rs: 72.50/52

(a) 724420

(b) 724619

(c) 725000

(d) 725200

4. The quotes for USD/INR is 74.30/32. What will be the 3 months outright forward quote if 3m Swap points are 30/29?

(a) 74.00/03

(b) 74.60/61

(c) 74.3030/3229

(d) None of the above

Notes

3.7 Summary

Currency forwards and futures are derivative instruments with foreign currencies as the underlying asset. Foreign currencies as an asset is considered to be an interest yielding asset as one can invest in foreign currency denominated securities issued by treasuries and earn a risk-free rate of return. Currency derivatives let people in the market trade and bet on the exchange rates between different currencies. Contracts for derivatives are based on common currency pairs, such as one can buy and sell USD/INR, EUR/INR, and GBP/INR. When there is no arbitrage possibilities: $F_o = S_o e^{(r- rf)t}$.

3.8 Answers to In-Text Questions

1. *(d)* All of the above

2. *(b)* Swap out transaction

3. *(a)* 724420

4. *(a)* 74.00/03

3.9 Self-Assessment Questions

1. Define hedging. Explain with illustrations.
2. Explain the various concepts of hedging with suitable examples.
3. Does hedging shield the investor from potential price swings? Do you concur with this assertion? Elaborate.
4. What does a hedging strategy mean to you? How will you develop a hedging plan as an investor?
5. Define hedge ratio. What role does the hedge ratio play in the creation of a hedging strategy?

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UNIT - III

LESSON

4

Mechanics of Option Market & Option Trading Strategies

STRUCTURE

4.1 Learning Objectives

- To establish the concept of Option Contracts.
- To develop and put into practice options trading strategies.
- To assess how risk and return function in options strategies and make wise investment choices.

Notes

4.2 Introduction

"Option" is a right that can be purchased and sold just like any other commodity. The option buyer is not obligated; they merely have the right. Regardless of changes in market prices, the buyer of an option has the right to purchase or sell any underlying assets, such as stocks, currency, or even other derivatives, at a defined price known as the strike or exercise price, on a certain date or within a specified time frame. In contrast, the option seller assumes the risk of having to accept delivery (for put) or deliver (for call). There are two categories of options, as stated in Chapter 1. With a call option, the option holder has the right to purchase the asset by a specific date at a specific price. The holder of a put option has the right to sell the asset at a specific price by a specific date. The maturity date, sometimes referred to as the expiration date, is the date that is stated in the contract. The exercise price, also referred to as the strike price, is the amount stated in the contract at which the call (put) buyer has right to buy (sell) the underlying.

There are two types of options: American and European. This difference is independent of geography. European options can only be exercised on the day of expiration; American options can be exercised whenever before the expiration date. American options make up the majority of those traded on exchanges. Though some of the characteristics of an American option may usually be inferred from those of its European counterpart, European options are generally simpler to evaluate than American options.

A financial agreement for both call and put options, the option contract is between the option buyer and seller. Option buyer pays the premium to option seller in exchange of the right. The holder purchases the option or right to purchase the underlying when they purchase a call, or long call. When the call buyer exercises their option to purchase the underlying, the call seller, i.e. the party with the short call position, assumes responsibility for delivering the underlying. Similarly, when the put buyer exercises their option, the put seller, also known as the short put, is theoretically obligated to accept delivery, and the put buyer (long put) purchases the right to sell the underlying. In exchange for accepting the responsibility to take delivery of the stock, the put buyer pays the put seller an option premium. Option trading may be done for speculative or arbitrage purposes. Call and put options may be purchased or sold by the buyer or seller based on their analysis of the underlying assets' markets.

Notes

4.3 Payoff on Option Contracts

Call buyer will exercise the option when the market price at the time of maturity is higher than the exercise price while put buyer will exercise the option when asset price at time of expiry is less than exercise price. Call & put sellers may benefit to the tune of premium received when options are not exercised by buyers whereas they'll have to bear loss in case options are exercised by buyers to the tune of profit made by buyers. Thereby payoff will differ for a different price at the time of maturity.

For instance, Mr. X purchases a call option with exercise price (K) of Rs. 100 for a premium of Rs. 20. Assume that the market price at the time of expiration is:

Table 4.1: Payoff for a call buyer at different market price.

Case	Price at the time of maturity (A)	Strike/ Exercise Price (B)	Exercising of Option-If A is more than B (C)	Option Premium Paid (D)	Net Profit/ (Loss) = (C) – (D)	Net Profit/ (Loss) To Call Seller
1	60	100	No	20	= 0 – 20 = (20) Loss	20
2	80	100	No	20	= 0 – 20 = (20) Loss	20
3	100	100	Indifferent	20	(20)	20
4	120	100	Yes Profit = 20	20	0 (break even)	0
5	140	100	Yes	20	40 – 20 = 20	(20)
6	200	100	Yes	20	80	(80)

As can be seen, call buyer net payoff increases as price of underlying increases so the payoff for a call buyer can be denoted as S_T – K and net payoff is equivalent to S_T – K – c where S_T is Price of underlying asset

Notes

at time of maturity; K is Exercise Price and c is call premium. It may also be noted that call buyer has unbounded profit while loss limited to premium value while opposite is true in case of call seller as his profit is limited to premium value while losses are unbounded. The payoff diagram for call buyer and seller is depicted in **Figures 4.1 and 4.2**.

Figure 4.1: Line chart showing payoff for Long Call.

Figure 4.2: Line chart showing payoff for Short Call.

Party with long put position will exercise the contract when price at the time of maturity is less than strike price. For instance, Mr. X purchases a put option with exercise price (K) of Rs. 100 for a premium of Rs. 20. Payoff for put buyer & put seller at varying market

Notes

Table 4.2: Payoff for a Put buyer at different market price.

Case	Price at the time of maturity (A)	Strike/ Exercise Price (B)	Exercising of Option- If A is more than B (C)	Option Premium Paid (D)	Net Profit/ (Loss) = (C) – (D)	Net Profit/ (Loss) To Put Seller
1	60	100	Yes	20	40 – 20 = 20	(20)
2	80	100	Yes	20	20 – 20 = 0	0
3	100	100	Indifferent	20	(20)	20
4	120	100	No	20	(20)	20
5	140	100	No	20	(20)	20
6	200	100	No	20	(20)	20

As can be seen, put buyer's net payoff increases as price of underlying decreases so the payoff for a put buyer can be denoted as $K - S_T$ and net payoff is equivalent to $K - S_T - p$ where S_T is Price of underlying asset at time of maturity; K is Exercise Price and p is put premium. The payoff diagram for put buyer and seller is depicted in Figures 4.3 and 4.4.

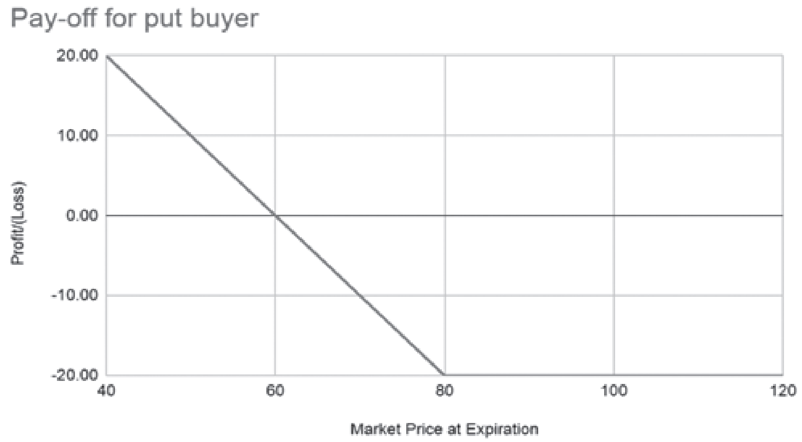


Figure 4.3: Line chart showing payoff for put buyer.

Notes

Figure 4.4: Line chart showing payoff for put seller.

Party with long call or put position pays option premium at the time of entry and when it squares off its position, earns a profit equivalent to difference in the exit option premium and entry option premium if the option premium or price has increased.

4.4 Factors Affecting Option Prices

Option premiums are influenced primarily by following six factors:

Increase in following factors	Impact on options			
	American		European	
	Call	Put	Call	Put
1. The current market value of the underlying asset, (S_0)	Increase	Decrease	Increase	Decrease
2. Strike Price (K)	Decrease	Increase	Decrease	Increase
3. The expiration time (T)	Increase	Increase	-	-
4. The stock price volatility (V)	Increase	Increase	Increase	Increase
5. The interest rate level (r)	Increase	Decrease	Increase	Decrease
6. The anticipated dividend (D)	Decrease	Increase	Decrease	Increase

Strike Price (K) and Stock Price (S_0): The value of call options increases with the stock price and decreases with the strike price. The amount by which the strike price of a put option exceeds the stock price is the payment upon exercise. Therefore, put options act differently from call options in that they gain in value when the strike price rises and decrease in value as the stock price rises.

Time to Expiry: As time to expiration gets closer, the value of both put and call American options decline as there is lesser time to exhibit volatility or bounce back into the money. Options with longer expiry will fare higher in values assuming no change in other characteristics.

Volatility: The likelihood that the stock may perform extremely well or extremely poorly rises with volatility. Because the maximum the buyer of a call may lose is the option's price, they gain from price gains but have little danger of a decline in value. In a similar vein, a put owner gains when prices decline but faces little chance of loss should prices rise. Volatility in underlying asset is a preferred characteristic.

Risk-Free Rate of Return: The price of an option is less directly impacted by the risk-free interest rate. Investors typically demand a higher expected return on their stock investments as interest rates rise in the economy. Rising interest rates increase return for call holder as there is deferred purchase while decreases return for put holder as there is deferred sale. Hence call value may increase while put value may decrease for increasing interest rates.

Dividend: Dividend income is foregone by call holder owing to postponed purchase hence dividend distribution may decrease call value while otherwise is true from put holders.

4.5 Upper Bound and Lower Bound on European Call option

Upper Bounds

The right to purchase one share of stock at a specific price is granted to the holder of an American or European call option. Hence, the option can never be worth greater than the stock. Therefore, the option price's upper bound is the stock price: S_0.

Lower Bounds

$S_0 - Ke^{-rt}$ is a lower bound on the European call option price for a stock that does not pay dividends.

Notes

Let us derive the lower bound using a numerical example:

S_0 is Rs. 200, K = Rs.180, r = 10% annually, and T = one year. $S_0 - Ke^{-rt}$ = Rs. 37.

Let's examine the scenario in which the European call price is Rs. 30. An arbitrageur may obtain a cash inflow of Rs. 200 - Rs. 30 = Rs. 170 by shorting the stock and purchasing the call. Investing Rs. 170 for a year at 10% annual growth yields Rs.187.9. The option expires at the end of the year. The arbitrageur closes out the short position, exercises the option for Rs. 180, and realizes a profit of Rs. 7.9 if the stock price rises over Rs. 180.

In the event that the stock price falls below Rs.180, the short position is closed and the stock is purchased in the market. At that point, the arbitrageur gains even more money. For instance, the arbitrageur will profit Rs.17.9 if the stock price is Rs. 170.

We can generalise the argument in following way:

Portfolio A: One European call option and a zero-coupon bond with a payout of K at time T.

Portfolio B: a stock.

At time T, Portfolio A is worth S_T (price at the time of maturity) when the call option is exercised at maturity if $S_T > K$. The portfolio is worth K and the call option expires worthless if ST is less than K. Therefore, portfolio A is worth max (S_T, K).

At time T, Portfolio B is worth S_T.

So portfolio A is always worth at least as much as or more than B at time t. It follows that this must still be the case now if there are no arbitrage opportunities.

Today, the zero-coupon bond is valued at Ke^{-rt}, call value is c and Stock present value is S_0 Therefore, either $c > S_0 - Ke^{-rt}$ or $c + Ke^{-rt} > S_0$

Call options cannot have a negative value because the worst that can happen to them is that they expire worthless. Since c > 0 in this case, $c > \max(S_0 - Ke^{-rt}, 0)$

Notes

4.6 Upper Bound and Lower Bound on European Put option

Upper Bounds

The right to sell a single share of stock for K is granted to the holder of an American or European put option. The value of the option can never be greater than K, regardless of how low the stock price drops.

Lower Bounds

$Ke^{-rt} - S_0$ is a lower bound on the European put option price for a stock that does not pay dividends.

Let us derive the lower bound using a numerical example:

S_0 is Rs. 370, K = Rs. 400, r = 5% annually, and T = 6 months. $Ke^{-rt} – S_0$ = Rs. 20.1.

Examine the scenario in which the European put price is Rs. 10, below the Rs. 20. An arbitrageur may borrow Rs. 380 for a six-month supply both the stock and the put. When the six months are up, the arbitrageur will be needed to repay Rs.389.6. In the event that the stock price drops to less than Rs. 400, the arbitrageur has the choice to return the loan, sell the stock for Rs. 400, and profit Rs. 389.6 = Rs. 10.4

In the event that the stock price rises above Rs. 40.00, the arbitrageur sells the shares, and then sells it back at a bigger profit.

We can generalise the argument in following way:

Portfolio A: One share and one European put option.

Portfolio B: A zero-coupon bond will pay off K at time T.

When the option in portfolio A matures, it is exercised if $S_T < K$. Portfolio increases in value by K. The put option expires worthless if $S_T >$ K, and currently, the portfolio is worth ST. Thus, portfolio A is valued at max (S_T, K) at T.

In time T, portfolio B is valued K. S_o portfolio A is always worth at least as much as or more than B at time t. It follows that this must still be the case now if there are no arbitrage opportunities. Hence cost of portfolio A and B $p + S_0 > Ke^{-rt}$ or $p > Ke^{-rt} - S_0$

Notes

4.7 Put call Parity Theory

One of the most important theories in option pricing is put-call parity. It establishes a relation between the price of put and call that have the same underlying assets. Put call parity theory can be derived considering 2 portfolios.

Portfolio A: One European call option and a zero-coupon bond with a payout of K at time T.

Portfolio B: One share and one European put option.

As discussed above, portfolio A is worth S_T (price at the time of maturity) when the call option is exercised at maturity if $S_T > K$. The portfolio is worth K and the call option expires worthless if S_T is less than K. Therefore, portfolio A is worth max (S_T, K).

Also, when the option in portfolio B matures, it is exercised if $S_T < K$. Portfolio increases in value by K. The put option expires worthless if $S_T > K$, in which case, the portfolio is worth ST. Thus, portfolio B is valued at max (S_T, K) at T.

Since both portfolios stated above have same payoff at time t, they must carry the same cost now otherwise arbitrage will set in to play.

Cost of Portfolio A: $c + Ke^{-rt}$

Cost of Portfolio B: So + p

$$\mathbf{S_o + p = c} + Ke^{-rt}$$

Where,

S_o = Spot price of underlying assets

c = European Call Option Price

p = European Put Option Price

r = Discount rate (often risk-free rate)

t = time to expiration

In case of dividend paying stock, the present value of dividend, discounted at risk-free rate should be deducted from $S_o + p$ or added to $\mathbf{c} + Ke^{-rt}$ for parity to prevail as call option holder forgoes dividends while put option holder retains dividend theoretically:

$$\mathbf{S_o + p = c} + Ke^{-rt} + D$$

Notes

If the above relation fails to hold between the variables that creates an opportunity for arbitrage. The formula given above also helps to find the value of any one variable if we know the value of the other three variables. This relation proves that the value of **forward contract** and a **portfolio of long European call with short European put** must be equal for the same underlying assets, expiration and strike price. If the value of both portfolios is not equal then this creates an opportunity for traders to employ strategies to make money.

For better understanding, let's consider a situation:

S_t (Spot price of underlying assets) = Rs. 100

C_t (Long Call Option Price/Premium paid) = Rs. 10

P_t (Short Put Option Price/Premium received) = Rs. 10

X (Strike Price) = Rs. 110

r (Discount rate i.e., risk-free rate) = 10 %

t = time to expiration = 1 year

Value of Long Call Option: Value of a long call or we can say call buyer can be calculated by analyzing whether the call buyer will exercise his option or not.

Table 4.3

Case	Market Price (A)	Strike/ Exercise Price (B)	Exercisation of Long Call Option: If A is more than B, (C)	Option Premium Paid (D)	Value of Long Call = (C) – (D)
1	200	110	Yes[1], Profit = 90	10	= 90 – 10 = 80
2	150	110	Yes[2], Profit = 40	10	= 40 – 10 = 30
3	100	110	No[3]	10	= 0 – 10 = (10)
4	50	110	No[4]	10	= 0 – 10 = (10)

Value of Short Put/Option:

Value of a short put can be measured by the viewpoint of the put buyer to understand whether the put buyer will exercise the option or not.

Notes

Table 4.4

Case	Market Price (A)	Strike/ Exercise Price (B)	Exercisation of short put: If B is more than A, (C)	Option Premium Received (D)	Value of Short Put = (D) – (C)
1	200	110	No	10	= 10 – 0 = 10
2	150	110	No	10	= 10 – 0 = 10
3	100	110	Yes[1], Loss = 10	10	= 10 – 10 = 0
4	50	110	Yes[2], Loss = 60	10	= 10 – 60 = (50)

Value of Forward Contract: Traders will buy in the spot market and will hold the underlying assets for 1 year. At the end of 1 year, traders will sell the assets in the market.

Table 4.5

Case	Spot Price (A)	Holding Cost for 1 year = 100*10/100 = 10 (B)	Total Cost (C)	Market Price (D)	Value of Forward Contract = (D) – (C)
1	100	10	110	200	= 200 – 110 = 90
2	100	10	110	150	= 150 – 110 = 40
3	100	10	110	100	= 100 – 110 = (10)
4	100	10	110	50	= 50 – 110 = (60)

Now, let's check whether:

Value of long call + Value of short put = Value of forward contract

Table A + Table B = Table C

Table 4.6

Case	Value of long call (Table A)	Value of short put (Table B)	Value of forward contract (Table C)	Table A + Table B = Table C	Holds the Parity True/ False
1	80	10	90	80 + 10 = 90	**TRUE**
2	30	10	40	30 + 10 = 40	**TRUE**
3	–10	0	–10	–10 + 0 = –10	**TRUE**
4	–10	–50	–60	–10 + (–50) = –60	**TRUE**

Notes

Illustration 1: The spot price of XYZ ltd is Rs. 380 and call for the same stock exercisable at Rs.440 in one-year period, is valued at Rs. 20. The return of riskless security is 10%. What will be the value of the put option with same underlying and exercise price of Rs. 440?

Solution:

Current Spot Price (S_t) = Rs. 380

Exercise Price (X) = Rs. 440

rf = 10 % = 0.1

call value = Rs. 20

As per put-call parity:.

$$S_t + P_t = C_t + Ke^{-rt}$$

$$380+P_t = 20 + 440*0.9048$$

$$P_t = 20 + 398.1284 - 380 = \text{Rs. } 38.12$$

If put price is not equal to Rs. 40, then there will be an arbitrage opportunity for the trader. Arbitrage is only possible when markets are not efficient.

4.8 Option Trading Spread Strategies

The payout of an option is the potential profit or loss that the holder may incur upon expiration, contingent upon the value of the underlying asset. It represents the financial gains or losses from exercising or holding the option contract.

Option strategies are preset combinations of options contracts that investors employ to control risk or reach certain financial objectives. These strategies involve buying and/or selling several options contracts at the same time, sometimes with different strike prices, expiration dates, and underlying assets. Option strategies are designed to generate income through option premiums, serve as hedging instruments, or capitalize on changing market conditions. By creating option strategies, investors can customize their holdings to fit their investing goals, level of risk tolerance, and market viewpoint. With these strategies, investors can protect their existing holdings, gain money from option premiums, profit from increases in the value of the underlying asset, and avoid losses.

Notes

Spread strategies include taking position in same type of options for example taking long & short position in either calls or puts. There are various strategies like Bull Spread, Bear Spread, Butterfly Spread etc.

Bull Call Spread Strategy

Purchasing a call option with a lower exercise price (say K_1) and concurrently selling a call option with a higher exercise price (say K_2) is known as a bull call spread. When an investor anticipates a price increase in the underlying asset, trader can resort to taking such position in the option market by which it can be sure of making a payoff equivalent to $K_2 - K_1$ in case price increases beyond K_2. In case price at the time of maturity falls below K_1, trader will incur a loss equal to c1 – c2 with c1 being call premium paid to purchase call and c2 being call premium received from selling call.

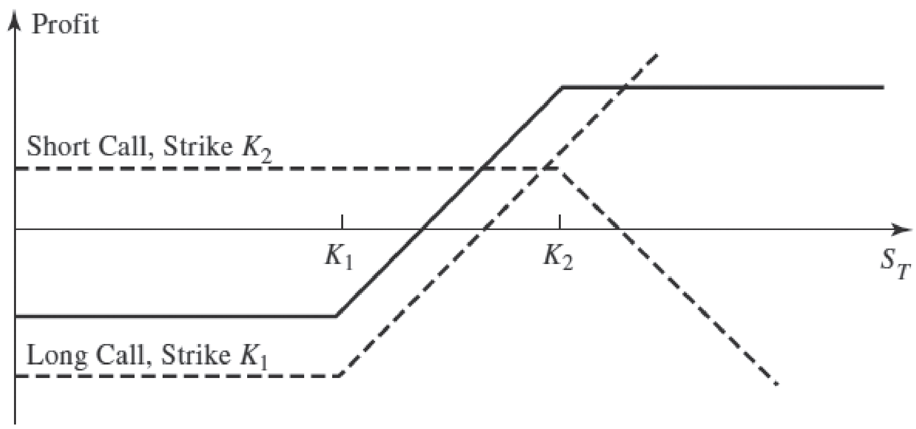


Figure 4.5: Payoff for Bull Call Spread

(Source: Hull, J.C. (2014). Options Futures and other Derivatives. 9th edition, Prentice Hall of India)

Let us say that an investor thinks there will be a rise in the price of Stock XYZ, which is now trading at Rs. 50, in the near future. An investor uses a Bull Call Spread method by making the following trades:

- For a premium of Rs. 4, purchase a call option with exercise price of Rs. 45.

- For a premium of Rs. 2, sell a call option with exercise price of Rs. 55.

Now let's figure out the profits and payoffs at expiration for various stock prices:

Stock Price at Expiration	Call Option 1 Payoff	Call Option 2 Payoff	Total Payoff	Net Profit
Rs. 40	Rs. 0	Rs. 0	Rs. 0	–Rs. 2
Rs. 45	Rs. 0	Rs. 0	Rs. 0	–Rs. 2
Rs. 50	Rs. 5	Rs. 0	Rs. 5	Rs. 3
Rs. 55	Rs. 10	Rs. 0	Rs. 10	Rs. 8
Rs. 60	Rs. 15	–Rs. 5	Rs. 10	Rs. 8

Both call options expire worthless if the price at expiration is less than the strike price of Rs. 45 (i.e., Rs. 40, Rs. 45). The entire premium paid, which is equal to Rs. 2 (Rs. 4 for Call Option 1 paid less Rs. 2 for Call Option 2 received), is forfeited by the investor. Two rupees is the net loss.

Call Option 1 is in-the-money and has a payment of Rs. 0 if the S_T is at the strike price of Rs. 45 (stock price - strike price = Rs. 45 - Rs. 45 = Rs. 0). Call option number 2 expires void. The net profit (total premium paid) is -Rs. 2, while the total payment is Rs. 0.

Call Option 1 is in-the-money with a payoff of Rs. 5 (Rs. 50 - Rs. 45) if the stock price at expiration is between the strike prices of Rs. 45 and Rs. 55 (for example, Rs. 50). Call option number two expires void. After deducting the total premium paid, the net profit is Rs. 3, and the final payment is Rs. 5.

Call Option 1 is in-the-money and pays Rs. 15 (Rs. 60 - Rs. 45) if the stock price at expiration is at or above the strike price of Rs. 60. Call Option 2 pays -Rs. 5 because it is likewise in-the-money. The net profit is equal to Rs. 8 (Rs. 10 - total premium paid), with a total payment of Rs. 10.

Bear Put Spread Strategy

A bear put spread buying a put with a higher exercise price and simultaneously selling a put at a lower exercise price. When an investor anticipates a slight drop in the value of the underlying asset, they will employ this strategy.

Notes

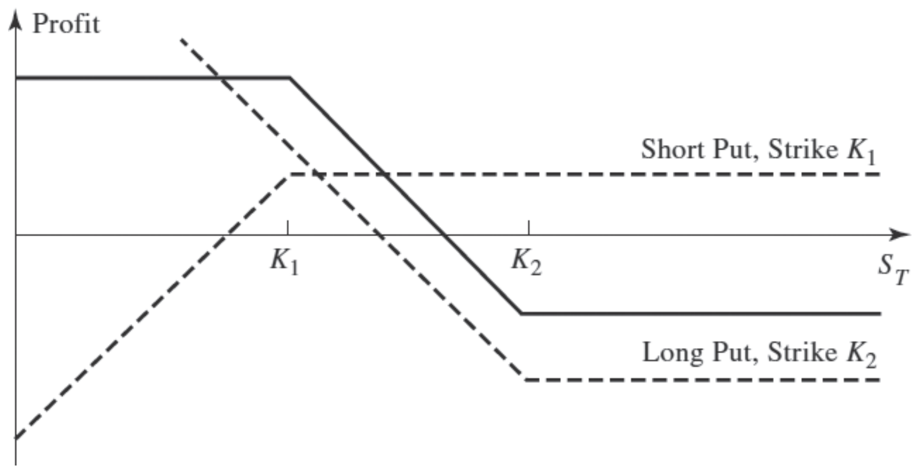


Figure 4.6: Payoff for Bear Put Spread

(Source: Hull, J.C. (2014). Options Futures and other Derivatives. 9th edition, Prentice Hall of India)

Assume that a stock is trading for Rs. 60. An investor pays a premium of Rs. 4 to purchase a put option with exercise price of Rs. 65. In parallel, the investor receives a premium of Rs. 2 for selling a put option with exercise price of Rs. 55. The investor can exercise the higher strike put option and profit by (Rs. 65 - Rs. 58 - Rs. 4) = Rs. 3 per share if the price at expiration is Rs. 58. The put option with the lower exercise would expire worthless.

Butterfly Spread Strategy

A butterfly spread strategy involves combining a bull and a bear spread. It is constructed by simultaneously buying and selling options with three exercise prices. When an investor expects minimal movement in the price of the underlying asset, they will employ this strategy. The strategy involves buying calls at K_1 and K_3; further selling two calls at K_2. K_2 should approximately be midway between K_1 and K_3 i.e. K_2 is approximately equal to (K1 + K3)/2. The payoff on butterfly strategy is depicted in figure.

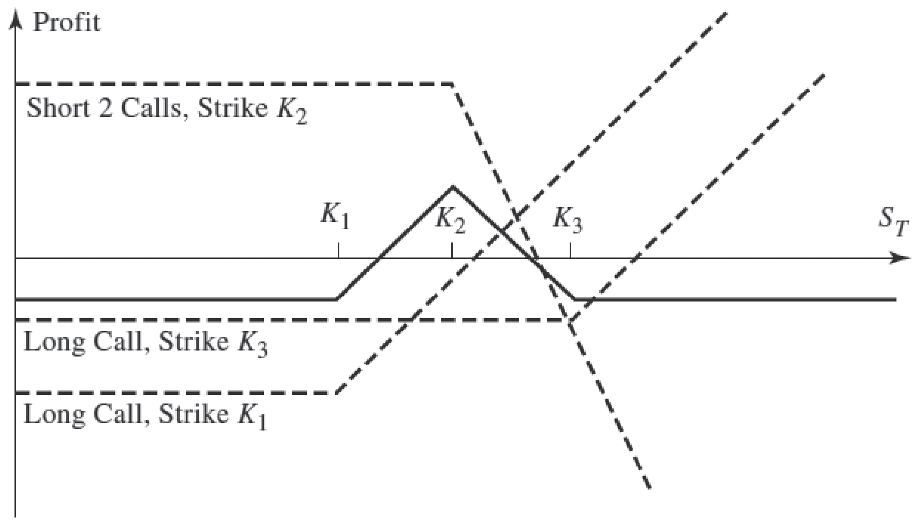


Figure 4.7: Payoff for Butterfly Spread

(Source: Hull, J.C. (2014). Options Futures and other Derivatives. 9th edition, Prentice Hall of India)

Assume that the asset price is Rs. 70. An investor pays a premium of Rs. 4 to purchase a call option with exercise price of Rs. 65. The investor receives a premium of Rs. 2 for each of the two call options that are sold simultaneously, each with exercise price of Rs. 70. Finally, the investor pays a premium of Re. 1 to purchase a call option with exercise price of Rs. 75.

Stock Price at Expiration	Call Option 1 Payoff	Call Option 2 Payoff	Call Option 3 Payoff	Total Payoff	Net Profit
Rs. 60	Rs. 0	Rs. 0	Rs. 0	Rs. 0	–Rs. 1
Rs. 65	Rs. 0	Rs. 0	Rs. 0	Rs. 0	–Rs. 1
Rs. 70	Rs. 5	Rs. 0	Rs. 0	Rs. 5	Rs. 4
Rs. 75	Rs. 10	–Rs. 10	Rs. 0	Rs. 0	–Rs. 1
Rs. 80	Rs. 15	–Rs. 20	Rs. 5	Rs. 0	–Rs. 1

None of the call options will be executed if the price is Rs. 60 at expiration. Thus, there will be an overall payout of Rs. 0. The investor must, however, pay a premium of Re. 1 (Rs. 4 for the first call option, Rs. 2 for each of the next two call options sold, and Re. 1 for the third call option purchased). Consequently, a loss of Rs 1 will be the net payment.

Notes

None of the call options will be executed if the stock price is Rs. 65 at expiration. Thus, there will be an overall payout of Rs. 0. The investor must, however, pay a premium of Re. 1 (Rs. 4 for the first call option, Rs. 2 for each of the next two call options sold, and Re. 1 for the third call option purchased). Consequently, a loss of Rs 1 will be the net payment.

Only the first call option, which has a Rs. 5 payout, will be exercised if the stock price reaches Rs. 70 at expiration. Hence, the total payoff will be Rs. 5. The investor must, however, pay a premium of Re. 1 (Rs 4 for the first call option, Rs. 2 for each of the next two call options sold, and Re 1 for the third call option purchased). Consequently, a loss of Rs. 4 will be the net payment.

Call options 1 and 2 will be exercised if the stock price is Rs. 70 at expiration. Call option 1 will result in a net payment of Rs. 10, and call option 2 would result in a loss of Rs. 10. Thus, there will be an overall payout of Rs. 0. The investor must, however, pay a premium of Re. 1 (Rs. 4 for the first call option, Rs. 2 for each of the next two call options sold, and Re. 1 for the third call option purchased). Consequently, a loss of Rs. 1 will be the net payment.

4.9 Option Trading Combination Strategies

Investing in both puts and calls on the same stock is known as a combination approach in option trading. There are variety of combination strategies a trader can deploy to leverage his/her expectations.

4.9.1 *Straddle Strategy*

A long straddle strategy is buying a call and a put with same underlying asset, same strike price and expiration date. This approach is profitable when market is expected to be volatile. This strategy is employed by investors who foresee significant price volatility in the underlying asset but are not sure about the direction of the price movement.

The objective of the Long Straddle strategy is to profit from significant price fluctuations in the underlying asset, regardless of whether the price swings upward or downward. By concurrently purchasing call and put options with the same expiration date and strike price, an investor employs the long straddle strategy. Premiums are required from the investor for both options. The call and put option premiums limit the risk associated with the long straddle strategy. The erosion of option premiums over time may result in maximum loss of total premium paid, particularly if the price of the underlying asset is generally stable and does not fluctuate substantially. Nonetheless, the potential profit is practically infinite if there is a significant move in the stock price in either direction.

Let us take an example of an investor who pays a premium of Rs. 5 for each call and put option that he buys on Stock XYZ with exercise price of Rs. 100. The call option will be in-the-money with a profit of Rs. 5 (Rs. 110 - Rs. 100 - Rs. 5) if the stock price is Rs. 110 at expiration. In a similar vein, the put option will expire out-of-the-money, incurring a Rs. 5 loss. In this case, the Long Straddle approach has a net payment of Rs. 0. In contrast, the put option will expire in the money with a profit of Rs. 5 (Rs. 100 - Rs. 90 - Rs. 5), and the call option will expire out-of-the-money with a loss of Rs. 5. This is assuming that the stock price at expiration is Rs. 90. In this instance, the net payoff is again Rs. 0.

The Long Straddle method is highly dependent on time. The strategy works best when there is a significant shift in the stock price throughout the option's term. The values of the selections may decrease over time due to time decay. When implementing a long straddle strategy, one should carefully evaluate the expected volatility level, the premium price of the options, and the time till expiry. This strategy requires a significant price movement to be profitable, so if the underlying asset stays stable over time, the investor may experience losses due to the erosion of option premiums. While taking no position on the direction of the price movement, investors can profit from large price movements in the underlying asset by using the Long Straddle method. Before using this technique, it's crucial to thoroughly evaluate the market circumstances, expectations for volatility, and level of risk tolerance.

Notes

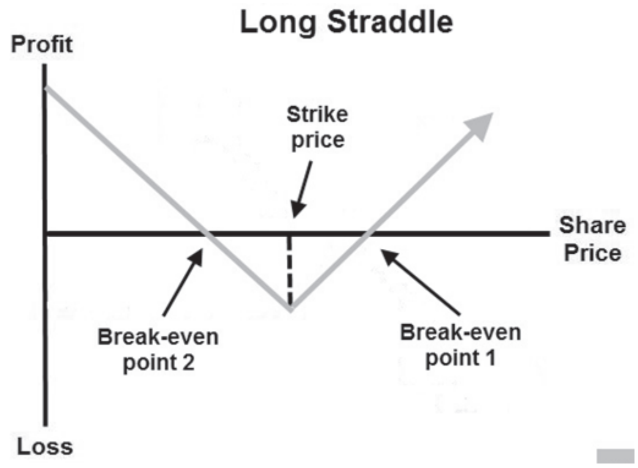


Figure 4.8: Payoff for Straddle Strategy

4.9.2 *Strangle Strategy*

An investor purchases a European put and a European call with the same expiration date and different strike prices in a strangle, also known as a bottom vertical combination. The figure displays the profit pattern. The price K2, the call strike price, is more than the K1 strike price for a put.

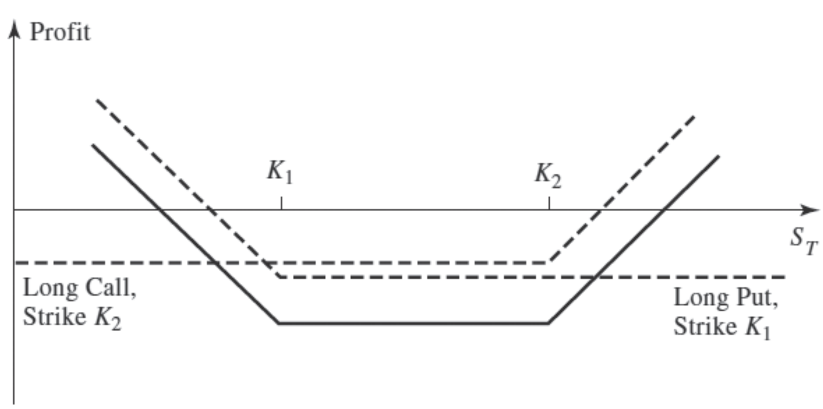


Figure 4.9: Payoff for Strangle Strategy

(Source: Hull, J.C. (2014). Options Futures and other Derivatives. 9th edition, Prentice Hall of India)

A straddle and a strangle are related strategies. The investor is placing a wager on a significant price movement, but they are unsure if it will be higher or lower but in order for an investor to profit, the stock price must move farther in a strangle than in a straddle. With a strangle, there is less risk and lower loss to the downside if the stock price reaches a center point.

Notes

The degree of proximity between the strike prices determines the profit pattern that can be achieved with a strangle. The less downside risk there is and the greater the distance the stock price must go before a profit is achieved, the farther apart they are.

A top vertical combination is another term used to describe the sale of a strangle. For an investor who believes significant fluctuations in stock prices are unlikely, it may be appropriate. But just like selling a straddle, it's a dangerous tactic with an infinite potential loss for the investor.

4.9.3 *STRIP and STRAP*

One long position in one European call and two long positions in two European puts with the same underlying, exercise price and days to expiry make up a strip. With the same strike price and expiration date, a strap is made up of a long position in two European calls and one European put.

Figure 4.10 displays the profit patterns from straps and strips. In a strip, the investor is placing a wager on the possibility of a significant change in the stock price and believes that a decline in price is more likely than a rise. In a strap, the investor is also speculating for a significant change in the stock price. But in this instance, it is thought that a rise in the stock price is more likely than a fall.

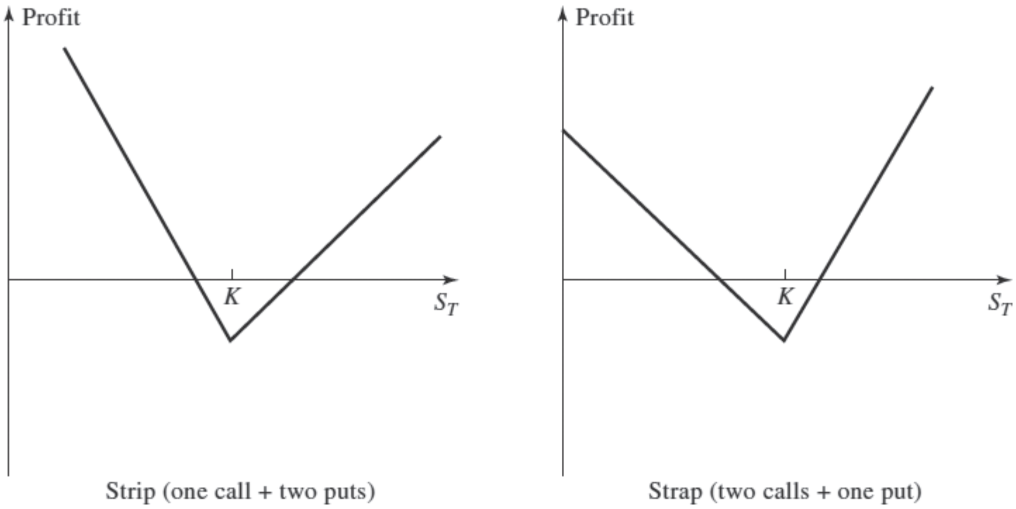


Fig. 4.10

(Source: Hull, J.C. (2014). Options Futures and other Derivatives. 9th edition, Prentice Hall of India)

Notes

IN-TEXT QUESTIONS

1. The main goal of a long straddle plan is to:

(a) Make money from the premiums paid

(b) Make money when the value of the underlying asset goes up a lot

(c) Make money when the price of the base asset drops by a lot

(d) Make money when the price of the base asset goes up or down a lot or when it changes direction significantly

2. Which of the following strategy is based on three different strike prices?

(a) Straddle

(b) Strangle

(c) Butterfly

(d) Strip

3. For a long straddle plan, the biggest loss that could happen is:

(a) The price paid for the call and put options together

(b) The difference between the strike price and the price of the underlying product on the market

(c) Any Amount

(d) None

4. Bull Spread is created by

(a) Buying a Call option on a stock with certain strike price and selling a Call option on the same stock with a higher strike price

(b) Buying a Call option on a stock with certain strike price and selling a Put option on the same stock with a higher strike price

(c) Buying a Put option on a stock with certain strike price and selling a Call option on the same stock with a higher strike price

(d) None of the above

4.10 Summary

A single option and the underlying stock are used in a number of popular trading methods. For instance, writing a protected put entails purchasing a put option and purchasing the stock, but writing a covered call entails purchasing the stock and selling a call option on it.

Selling a put option is comparable to the former, and purchasing a call option is comparable to the latter.

Investing in spreads entails holding positions in two or more puts or calls. Purchasing a call (put) at a low strike price and selling a call (put) at a high strike price can result in a bull spread. Purchasing a put (call) at a high strike price and selling a put (call) at a low strike price might result in a bear spread.

Purchasing calls (puts) with low and high strike prices and selling two calls (puts) with a middle strike price constitute a butterfly spread. Selling a call (put) with a short expiration period and purchasing a call (put) with a longer expiration date constitute a calendar spread. When the strike price and expiration date of two options are different, a diagonal spread is when one option is long and the other is short.

Investing in calls and puts on the same stock is known as a combination. Taking a long position in a call and a long position in a put with the same strike price and expiration date is known as straddle combination trading. A long position in one call and two puts with the same strike price and expiration date makes up a strip. Two long positions in calls and one put with the same strike price and expiration date make up a strap.

A strangle is a long position in both a put and a call option with the same expiration date but different strike prices.

4.11 Answers to In-Text Questions

1. *(d)* Make money when the price of the base asset goes up or down a lot or when it changes direction significantly
2. *(c)* Butterfly
3. *(a)* The price paid for the call and put options together
4. *(b)* Buying a Call option on a stock with certain strike price and selling a Put option on the same stock with a higher strike price

Notes

4.12 Self-Assessment Questions

1. A bear spread is made when an investor sells a 6-month put option with a strike price of \$25 for \$2.15 and buys a 6-month put option with a strike price of \$29 for \$4.75. How much is the original investment? What is the total return on investment, minus the original investment, when in six months, the stock price will be (a) \$23, (b) \$28, or (c) \$33?
2. Using put options, explain how to make bear spread.
3. Suppose that the
   - Stock price of a stock is 250
   - Strike price of options is 250
   - Risk-free interest rate is 8% per annum
   - Price of a 5-month European call option is 32
   - Price of a 5-month European put option is 25

Does an arbitrage opportunity exist? If yes, tell us what trades you will execute to earn risk-free profit. Suppose the stock's closing price is Rs.1000 on the option's expiration day.

4.13 References

- Hull, J. C. (2014). Options Futures and other Derivatives. 9th edition, Prentice Hall of India.
- Neftci, S. N. (2000). An Introduction to the Mathematics of Financial Derivatives. Academic Press.

UNIT - IV

LESSON

5

Option Pricing Model

STRUCTURE

5.1 Learning Objectives

- To comprehend the basic ideas behind option pricing, as well as the role it plays in financial derivatives.
- To explain how to build a binomial tree for option pricing and the assumptions of the binomial option-pricing model.
- To comprehend how the binomial model is used to calculate option prices, including the pricing of put and call options.
- To understand the working Black Scholes Merton Option Pricing Model.

5.2 Introduction to Option Pricing

The strike price, often referred to as the exercise price, is the declared and predetermined price at which the holder of an option may purchase the underlying asset or sell it (for call and put options, respectively). It is one of the most important components of an

Notes

option contract and is stated at the moment the option is formed. The terms "out of the money" (OTM) and "in the money" (ITM) refer to the relationship between an option's strike price and the market price of the underlying asset. They represent the following:

An option is "out of the money" (OTM) if the current price of the underlying asset makes it difficult for the option holder to exercise the option and make money doing so. This demonstrates that the strike price of a call option is more than the market price of the underlying asset. This indicates that the put option's underlying asset's market price is greater than the strike price. Put differently, the holder would incur a loss if the option were exercised at the current market price.

An option is said to be "in the money" (ITM) when the price of the underlying asset makes executing the option advantageous for the option holder and potentially profitable. This indicates that the strike price of a call option is below the market price of the underlying asset. This demonstrates that a put option's strike price is less than the underlying asset's current market value. Put differently, the option holder would benefit if the option were exercised at the current market price. Being "in the money" or "out of the money" for an option affects the potential profitability and decision-making abilities of the option holder. An in-the-money option frequently has a higher value or premium than an out-of-the-money option because of its intrinsic value. Traders and investors typically consider an option's ITM/OTM status when determining whether to sell, exercise, or retain the option for potential future price fluctuations.

The striking price, the amount of time till the option expires, the underlying asset's price volatility, and the current market price are some of the variables that affect an option's value and pricing. A call option may still have some value even though it is out of the money or the stock price is below the exercise price. There's always the possibility that the stock price will rise enough before the expiration date to make it profitable to exercise the call option, even though it's now out of the money and would be a loss if done so right then. The potential for the stock price to rise and become profitable gives the call option its value.

When calculating the option's value, the price of the underlying stock is also considered in addition to the expiration date. Due to the option's falling time value and the possibility of stock price swings, the option's value may alter as time goes on and the expiration date draws near.

The worst-case situation for an out-of-the-money call option is for it to expire worthless. This implies that the option holder's maximum loss is limited to the option premium. Even if there is always a potential that the stock price may rise and the option will become profitable, the option holder may decide to keep the option until it expires.

5.3 Conceptualizing Binomial Option-Pricing Model (BOPM)

One frequently applied mathematical model for pricing options is the Binomial Option-Pricing Model (BOPM). Since its creation by Cox, Ross, and Rubinstein in 1979, it has developed into an essential tool for financial derivatives pricing. The BOPM, a discrete temporal and discrete state model, provides a rapid and simple method for estimating the possible cost of decisions.

The importance of option pricing in the context of financial derivatives cannot be overstated. Financial contracts known as options give its holders the right, but not the obligation, to purchase or sell the underlying asset at a specific price, also referred to as the exercise price or striking price, within a specified period of time. Option pricing is crucial for a variety of market participants, including traders, investors, and financial institutions, as it enables them to develop trading strategies, control risks, and make well-informed investment decisions. Because of its adaptability and simplicity of usage, BOPM is widely used in the financial industry. It provides a methodology for assessing options by accounting for the probabilistic price fluctuations of the underlying asset across discrete time steps. The model includes certain assumptions regarding discrete time and state, risk-neutral pricing, and binomial distribution of stock price movements in order to simplify the valuation process. By building a binomial tree to depict probable changes in stock prices and associated option values, BOPM allows option prices to be computed at each node of the tree, leading to the theoretical value of the option. One must understand the fundamental ideas of BOPM as well as the construction of a binomial tree in order for the concept to make sense. The fundamental presumptions of BOPM and the methodical procedure for building a binomial tree for option pricing will be discussed in the following sections.

Notes

5.3.1 *BOPM Assumptions*

A number of fundamental presumptions underpin the Binomial Option-Pricing Model (BOPM), which streamlines the valuation process and gives option pricing practitioners access to a potent tool.

1. **Discrete Time and Discrete State Model:** The basis of BOPM divides time into discrete phases and the price of the underlying asset into different amounts. This suggests that the model considers just a restricted set of time periods and possible variations in the price of the underlying asset during each period. This discrete time and discrete state assumption allows for a more controlled and computationally efficient valuation process compared to continuous time models.
2. **Risk-Neutral Pricing Assumption:** BOPM bases the pricing of its options on the assumption that investors do not care about risk and that the market is risk-neutral. Because of this, it is simple to compute expected option values using risk-neutral probabilities, which are derived from the likelihood of the several possible stock price movements in the binomial tree. Risk-neutral pricing, which is used to discount future anticipated option prices to their current value, is a key concept in BOPM.
3. **Binomial Distribution of Stock Price Movements:** The assumption made by BOPM that the stock price can only rise or fall by a particular percentage at each time step leads to a binomial distribution of possible price movements. Stock price movements are easier to model since there are just two possible outcomes (up or down) for each time step. The probabilities associated with these movements are used to calculate the option values at each node of the binomial tree.
4. **Lack of Arbitrage Opportunities:** BOPM's presumptions are predicated on the notion that there are no opportunities for arbitrage in the market, making it impossible to profit risk-free from price differences. This supposition ensures that the model produces non-profitable, realistic, and consistent option pricing.

Because of these suppositions, the BOPM model for option pricing is quite simple and easy to grasp. It is important to remember that these assumptions do not always fully reflect the dynamics of financial markets when using BOPM for pricing options in real applications. Their limits ought to be considered as a result.

The next section will address the building of a binomial tree for option pricing, which is an essential step in utilizing BOPM to calculate option prices.

IN-TEXT QUESTIONS

1. Which of the following is an assumption of the Binomial Option Pricing Model?

(a) The underlying asset's price follows a continuous geometric Brownian motion

(b) The underlying asset's price can only move up or down by a fixed percentage each time period

(c) The risk-free rate of return is constant over the life of the option

(d) None of the above

2. One of the assumptions of the BOPM is that there are no transaction costs, taxes, or restrictions on short-selling. (True/False)

5.3.2 *Hedge Ratio in Binomial Tree for Option Pricing*

The hedging ratio is a fundamental concept in the Binomial Model, which establishes the value of options. It is a gauge of the option's price sensitivity to the underlying asset's value. The hedging ratio expresses precisely how many units of the asset need to be bought or sold in order to offset the risk associated with holding the option.

To gain a better understanding of the hedging ratio, let us first review the BOPM's foundations. The BOPM is a mathematical model used to evaluate options that simulate the price evolution of the underlying asset over time. The concept suggests that the price of the underlying asset may only fluctuate by a certain amount during each time period and that the likelihood of the asset going up or down is known. The model calculates the option price at each time interval by working backwards from the expiration date using these suppositions as a foundation.

The hedging ratio is relevant when an investor chooses to buy or sell the underlying asset to protect their position in the option.

Notes

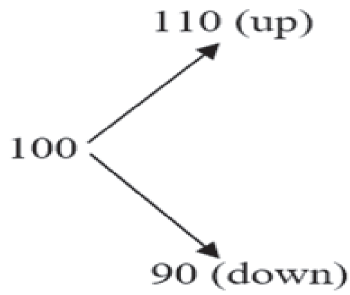
The mathematical notation for the hedging ratio is H = Δf /ΔS or = ($f_1 - f_0$)/($s_1 - s_0$) where Δf is the change in the option price, ΔS is the change in the price of the underlying asset, and H is the hedge ratio. This hedge ratio for option is sensitivity of option's price to market price of underlying asset. The number of units of the underlying asset that must be purchased or sold in order to fully hedge the position in the option is indicated by the hedge ratio. This hedge ratio for options is commonly known as **Delta**.

Consider the following scenario: we have a call option on a stock that has a strike price of Rs. 50 and a current price of Rs. 45. With a delta of 0.7, the option will see an increase in price of Rs. 0.70 for every Rupee that the value of the underlying asset rises. We would need to purchase 0.7 units of stock for every one unit of the option we own in order to hedge our position. The option price would rise by Rs. 3.5 (Rs. 0.70 × 5) if the stock price increased to Rs 50. This would completely balance any potential losses in the option and enhance the value of our hedge position in the stock by Rs. 3.5.

5.3.3 *Decision Trees with One Step and Two Steps Binomial Model*

One-step Binomial Tree: To understand the pricing model, let's assume a call option with strike price of Rs. 105 & underlying asset trading at Rs. 100. We predict that during the next month, the stock price will rise or fall by 10%. Suppose Δ is number of shares held, portfolio shall be worth 110 Δ if price goes up and 90 Δ if price falls.

We may begin with the current stock price of Rs. 100 and construct the one-step binomial tree illustrated below:



The value of the call option is determined at each node by taking the maximum of two values: zero and the difference between the strike price

Notes

and the current stock price. For example, max (110 - 105, 0) = 5 is the call option value at the up node. At the down node, the call option value is max (90 – 105, 0) = 0.

Let's suppose a risk-neutral portfolio is created by buying shares and selling call. In a risk-free portfolio, there is no uncertainty about the return and risk-free rate of return is expected to be earned regardless of the direction in which the price moves.

So $110\,\Delta - 5 = 90\Delta$

$\Delta = 0.25$

So value of portfolio at the end of month = 110 * .25 – 5 = 22.5

Cost of portfolio if risk-free rate of return is 10% per annum, must be $22.5e^{-rt}$

Portfolio comprises 25 shares bought and 1 call sold. Hence:

$100*0.25 - f = 22.5e^{-.1*1/12}$

$f = 2.685$

f denotes the price of call.

To generalise above numerical derivation in algebraic form, let's assume the following:

f_u = Option value if price goes up

f_d = Option value if price falls

S_{0u} = Asset price when price rises

S_{0d} = Asset price when price falls

S_0 = Current price of underlying asset

f = Current Option price

In a risk-neutral portfolio where asset is bought and call is sold, the value after a month shall remain same whether price rises or falls. It may be depicted as:

$S_0u\,\Delta - fu = S_0d\,\Delta - fd$

$\Delta = (f_u - f_d)/\,(S_{0u} - S_{0d})$

Δ depicts delta which rate of change of option value with respect to change in underlying asset price. Hence it denotes the hedge ratio as explained under section 1.3.2.

Notes

Now present value of portfolio can be denoted as $e^{-rt} *(S_0 u \, \Delta - fu)$

Cost of portfolio is $S_0 \, \Delta - f$

So $S_0 \, \Delta - f = e^{-rt} *(S_0 u \, \Delta - fu)$

Substituting the value of Δ and simplifying for f

$f = S_0 * ((f_u - f_d)/ (S_{0u} - S_{0d})) * (1 - ue^{-rT}) + fue^{-rT}$

Further simplifying it

$\mathbf{f = e^{-rt} (p*f_u + (1\text{-}p)f_d)}$

where $\mathbf{p = (e^{rt} - d)/(u\text{-}d)}$

p is the probability of price rise. u – 1 is percentage rise in underlying while 1 – d is percentage fall in underlying.

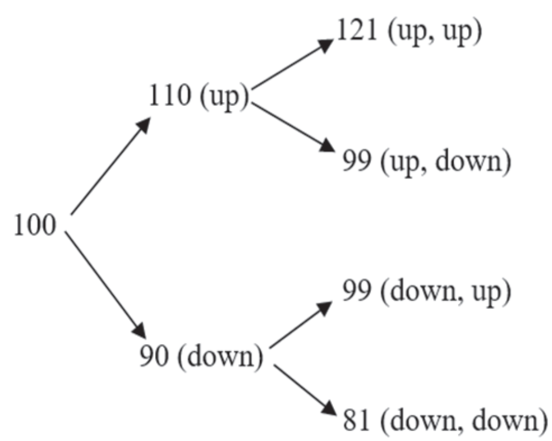
So, to conclude the option value at the root node is ascertained by starting at the end of the tree and proceeding backwards. The option value at the root node is equal to the discounted anticipated value of the two possible outcomes.

So value of option using Binomial option pricing model is

$f = e^{-rt} (p*fu + (1–p) \, fd)$

Two-step Binomial Tree:

Assume for the moment that we wish to price a call option on a stock that is now trading at Rs. 100 with a strike price of Rs. 105 using a two-step binomial tree. We predict that during the course of the next month, there is an equal chance that the stock price will rise or fall by 10%. We may begin with the current stock price of Rs. 100 and construct the two-step binomial tree illustrated below:



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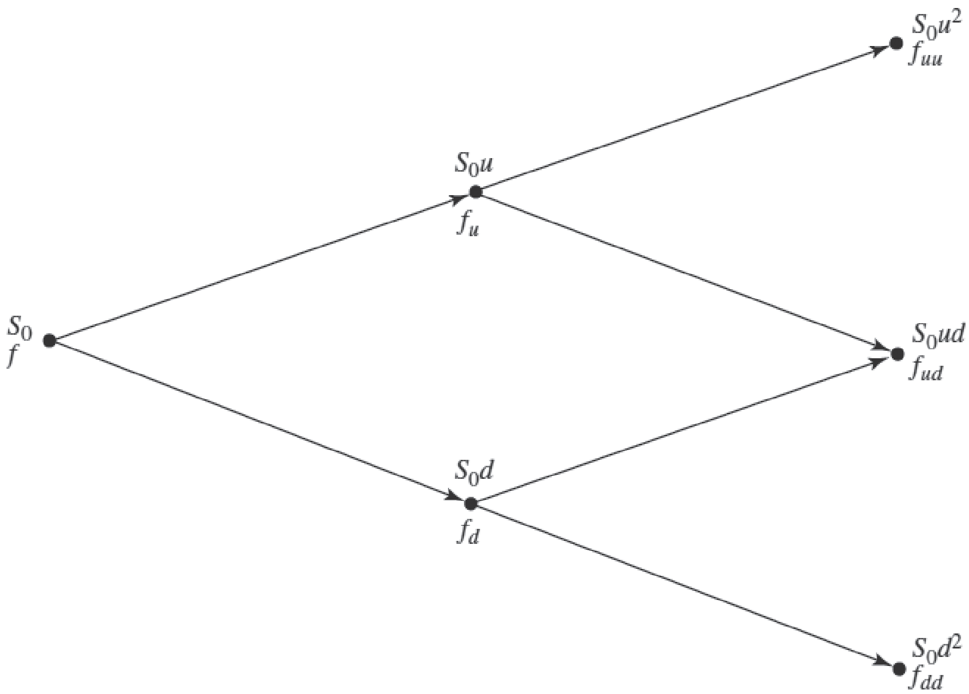

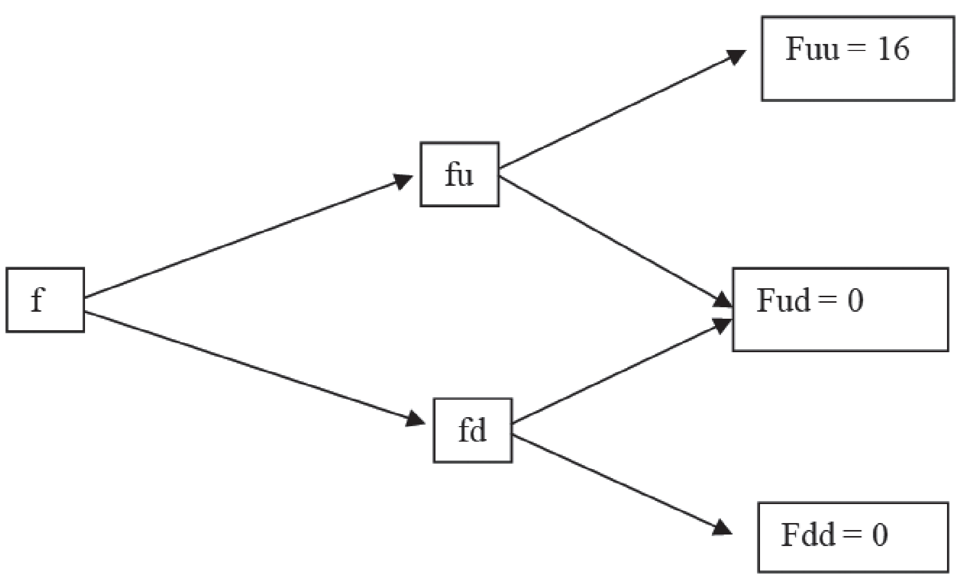

To find the call option value at each node, we follow the same procedure as in the one-step binomial tree example. As an example, the call option values at the up-up node are max (121 – 105, 0) = 16, at the up-down node they are max (99 – 105, 0) = 0, at the down-up node they are 0 and at the down-down node they are max (81 – 105, 0) = 0.

Notes

Since the down-up and up-down nodes both display the same call option value with a 0.25 probability each, we can simply aggregate these probability values. Next, starting at the end of the tree and proceeding backwards, the option value at the root node is ascertained. The option value at the root node is equal to the discounted anticipated value of the three possibilities in this case, which is (0.5 * 0 + 0.25 * 16 + 0.25 * 0)/(1 + r). R is the interest rate at no risk.

After computing the option value at the root node, the option price can be ascertained. The option value at the root node's present value, discounted at the risk-free interest rate, is the option price, to put it simply. For example, if the option value at the root node is Rs. 6 and the risk-free interest rate is 3%, the option price is Rs. 16/(1 + 0.03) = Rs. 15.53.

It is important to keep in mind that the accuracy of the binomial tree model is dependent on the number of stages used in the tree construction process. Generally speaking, the more phases used, the more accurate the option pricing will be. However, the model's computational complexity also increases with a higher number of steps.

Value of option using Binomial option pricing model is

$f = e^{-r\Delta t}(p*fu + (1-p)fd)$ … (1)

Where

f is the value of option.

$fu = e^{-r\Delta t}(p*fuu + (1-p)fud)$

$fd = e^{-r\Delta t}(p*fdd + (1-p)fdu)$

p is probability of price of underlying going up.

Incorporating value of fu and fd in equation (1), we get

$$\mathbf{f = e^{-2r\Delta t}(p^2*fuu + 2p(1-p)fud + (1-p)^2fdd)}$$

5.4 Calculating Option Prices Using Binomial Model

A binomial tree is used in this mathematical model to depict an option's possible outcomes. According to this theory, the expected value of an option's payment at any given time determines the option's value. The binomial tree is produced by dividing the time period into a number of equal segments and assuming that underlying asset's price may only increase or decrease at each interval. The degree to which the price will rise or fall depends on the return variability of the underlying asset. The possibility of an upward advance is calculated using the risk-neutral probability, which is based on the assumption that the expected return on the underlying asset is equal to the return earned on riskless asset.

The Binomial Model (BOPM) is usually used to calculate option prices in the following four steps:

1. **Assemble the Binary Tree:** This entails splitting the time interval into multiple equal segments and calculating the magnitude of the underlying asset's upward and downward movements using a measure called volatility.
2. **Determine the Up and Down Factors:** We can determine the up and down components in the model by using the stock's volatility, the time period for each step in the model, and the risk-neutral probability of an up or down move.

The stock's volatility, the time step, and the risk-neutral probability of an up or down move are used to compute the up and down components in the Binomial Option Pricing Model.

The formula for calculating the up factor (u) is $e^{(\sigma \sqrt{\Delta t})}$, where σ represents the annualized volatility of the stock, Δt is the time interval for every step in the model, and e is the mathematical constant 2.71828.

The up factor's reciprocal, or d, is the down factor: d is equal to 1/u.

The up and down factors can be calculated as follows, for instance, if the stock's volatility is 20%, the time interval for each step is 1 year/12 months = 1/12, and the risk-neutral probability of an up or down move is 0.5.

$$u = e^{(\sigma\sqrt{\Delta t})} = e\text{^ } (0.2\sqrt{\ }(1/12)) = 1.0134$$

$$d = 1/u = 0.9868$$

The binomial tree for the stock price may then be built using these up and down components, and the expected payoffs of the option at each node of the tree can be determined.

1. **Determine the Option Payoff:** At the conclusion of the maturity period, the option payoff for each potential outcome is determined using the built binomial tree.
2. **Calculate the Option Value at Each Node by Working Backwards:** The option value at each node is determined by calculating the

Notes

discounted expected value of the two possible outcomes at that node, beginning at the end of the binomial tree.

3. **Determine the Option Price:** The option value at the binomial tree's root is used to calculate the option price.

To illustrate the binomial model, let's take a look at a call option on a stock that has a strike price of Rs. 50, a one-year period, and a 20% volatility. The stock price is Rs. 45 at the moment, and the risk-free rate is 5%.

First, we need to construct a binomial tree to model possible variation in the stock's price over time. Since there is an equal chance of traveling up or down the tree, we can assume a risk-neutral probability of 0.5 for each node in the tree. Over two time periods, the asset price at each node in the tree will either increase or fall by a factor of u or d.

With the 20% volatility that has been provided, we may compute the up and down factors as follows: $u = e^{(\sigma\sqrt{\Delta t})} = e^{(0.2\sqrt{(1/2)})} = 1.1519$

$d = 1/u = 0.8681$

We can determine the two potential prices at the conclusion of the first time period using the present stock price of Rs 45:

Up is Rs. 51.83 (45 × 1.1519).

Lower = 45 x 0.8681 = Rs. 39.06

The two potential prices at the conclusion of the second time period can then be determined:

Up-Up equals Rs. 59.70 (51.83 × 1.1519).

51.83 × 0.8681 = Rs. 44.99 is the Up-Down.

Down-Down: Rs. 33.90 = 39.06 × 0.8681

The call option payoffs at each node in the tree must then be determined. A call option's payoff is equal to difference between expected value of asset & the exercise price of the option or zero, whichever is higher.

The payouts at the conclusion of the second time frame are:

Max (0, 59.70 – 50) = Rs 9.70 is the Up-Up.

Max (0, 44.99 – 50) = Rs 0 for Up-Down

Maximum (0, 33.90 – 50) – Down-Down = Rs. 0

We can then compute the expected payoff of the call option at the conclusion of the first time period using the risk-neutral probabilities:

At t = 1, the anticipated payout is (0.5 × Rs. 9.7) + (0.5 × Rs. 0) = Rs. 4.85.

Using the risk-free rate, we can then discount this anticipated payout back to the present. The anticipated payoff's present value is:

Expected payout present value: Rs. 4.85/(1 + 0.05)^1 = Rs. 4.619

As a result, based on the Binomial Option Pricing Model, the current price of the call option is roughly Rs. 4.619.

5.5 Black Scholes Merton Option Pricing Model

By theorizing "The Black-Scholes Model" in 1970, Fischer Black, Myron Scholes, and Robert C. Merton made a substantial contribution to the options pricing. This is often referred to as "The Black-Scholes-Merton Model" because it was initially proposed by Robert C. Merton, after which Fischer Black and Myron Scholes came up with the equation and the model. It is now also being used to value real options. The return variability, underlying stock price, strike price, period, and riskless rate of return are the six factors that the BSM model uses to figure out what a stock option is worth. It is based on the idea of hedging and aims to lower the risks that come with the volatile nature of stock options and real assets.

The Black Scholes Merton Model is a mathematical formula that evaluates the potential value of pricing options by considering six key factors: the nature of the option (call or put), stock price, striking price, risk-free rate, volatility, and time. It provides a mathematical model of the derivatives found in the financial market. The main objective of the model is to minimize losses or maximize gains by hedging various choices for purchasing and selling the invested assets.

The model uses the present value and the change in value of the underlying asset, the strike price, the time until the option expires, and the riskless interest rate to figure out how much an option is worth. The model assumes that the prices of stocks follow a log normal distribution. This is another thing that the Black-Scholes model assumes:

There are no profits during the life of the option.

Notes

Since markets are random, it is hard to accurately predict how they will change.

There are no processing fees when you buy the option.

The risk-free rate and volatility of the underlying product are always the same.

The returns on the base asset are spread out correctly.

European choices can only be used when they expire.

The Black-Scholes call option formula is calculated by multiplying the stock price by the cumulative standard normal probability distribution function. Thereafter, the Net Present Value (NPV) of the strike price multiplied by the cumulative standard normal distribution is subtracted from the resulting value of the previous calculation.

In mathematical notation:

$c = SN(d_1) - Ke^{-rt} N(d_2)$

$p = Ke^{-rt} N(d_2) - SN(d_1)$

where:

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

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

where:

c = call premium

p = put premium

s = spot price

K = exercise price

r = risk free rate of return

T = time to maturity

σ = daily volatility of underlying asset

The term Nd_2 in equation is the probability that a call option will be exercised in a risk-neutral world. The expression $S_0Nd_1e^{rt}$ is the expected stock price at time T in a risk-neutral world when stock prices less than the strike price are counted as zero.

Notes

Illustration 7.3 The current stock price is $42 and option underlying the same asset will expire in 6 months. The exercise price is $40, 10 % is risk free rate of return in the market and 20% is annual volatility. Find the theoretic price of the call option using Black Scholes Merton Model.

Solution: $\mathbf{d_1} = \dfrac{\ln\left(\frac{42}{40}\right)+\left(0.1+\frac{0.2^2}{2}\right)*0.5}{\mathbf{0.2\sqrt{0.5}}} = \mathbf{0.7693}$

$\mathbf{d_2} = 0.7693 - \mathbf{0.2\sqrt{0.5} = 0.6278}$

c = 42 N(0.7693) – 38.049 N(0.6278) = 42* 0.7791 – 38.049 * 0.7349 = 4.76

Limitations and Assumptions of Black Scholes Merton Model

Although the model is extensively used and serves as the foundation for options pricing theory, it is limited by a number of assumptions. Here are a few of them:

1. **Market Efficiency:** The Black-Scholes model is predicated on the idea that markets are efficient, which implies that the price of the underlying security reflects all pertinent information. In actuality, information asymmetry and market frictions may impact option prices, and markets may not always be completely efficient.
2. **Constant Volatility:** The model makes the assumption that during the term of an option, the underlying security's return volatility will be constant. In actuality, volatility might fluctuate over time, which could cause the model's forecasts to be inaccurate. Several extensions have been suggested to overcome this restriction, including the application of stochastic volatility models.
3. **Continuous Trading:** The strategy is predicated on the idea of continuous trading, which eliminates transaction fees and trading limitations. In actuality, trading restrictions, transaction costs, and liquidity problems can affect how much an option is priced and how to trade it.
4. **Log-normal Distribution:** The Black-Scholes model postulates that the returns of the underlying security are influenced by a log-normal distribution. Although this assumption is frequently valid for brief periods of time, it might not be true over longer time horizons since asset returns can have skewness and kurtosis that the model does not account for.

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5. **No Cash Flows or Dividends:** The model makes the assumption that during the term of an option, the underlying security will not provide any cash flows or dividends. This presumption does not apply to options on dividend-paying equities or to specific categories of derivative products.
6. **Risk-free Interest Rate:** The model makes the assumption that throughout the term of an option, the rate of risk-free securities is known and will not change. Interest rates can fluctuate in real life, which could cause uncertainty in the model's price computations.
7. **No Taxes and No Transaction Costs:** The Black-Scholes model makes the assumption that there are no taxes or transaction costs, which has a big impact on the profitability of option trading and real-world pricing.
8. **No Market Manipulation:** The model makes the assumption that there are no abnormalities in the market, including market manipulation. In actuality, though, a number of the model's suppositions can be refuted by various forms of market manipulation and other variables, which can affect pricing.

As an illustration:

Assume the option has 103 days remaining until it expires and that the annualized risk-free rate for that time period is 4.63%. The current stock price (S) is $13.62, the option's strike price is $15, and the stock prices' standard deviation is 81%.

Option life in this case is 103/365 = 0.2822.

The model yields the following results when these values are entered: d1 = (In (13.62/15.00) + (0.463 + .812/2)*.2822)).81. √.2822 = .0212 d2 = .0212 –.81. √.2822 = .4091

We may estimate the N(d1) and N(d2) using the normal distribution: N(d1) = .5085 N(d2)) = .3412

At this point, the call's worth can be calculated:

C = X. e-rt. N(d2) – S. N(d1)

C is equal to 13.62 (.5085)-15 e-(0.463)(0.2822) (0.3412) = $1.87

Given that the call is selling at $2, it is overvalued, assuming that the standard deviation estimate that was employed is accurate.

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5.6 Extension of Black-Scholes Formula

It is critical to understand the underlying presumptions and constraints when using the Black-Scholes model to valuation. To take into consideration more variables and complexity in option pricing, the Black-Scholes formula has been expanded upon and altered in a number of ways. One of the major BSM assumptions is that the underlying security is assumed to not pay dividends. But in actuality, a lot of securities have dividend payments. Changes have been made to the formula's parameters to include dividend payments in the model.

Dividends can be included in the model in one of two ways:

1. **Short-term Options:** One method for handling dividends in a short-term option is to calculate the present value of all anticipated dividend payments made by the underlying security during the option's life and deduct it from the asset's current value in the model.

   Stock price - PV of anticipated dividends (during option life period) equals the modified stock price.

   But when an option has a long life, it becomes impossible to estimate the present value of dividends. As a result, we must take a different strategy.

2. **Long-term Options:** An efficient way to handle dividends during an option's extended life is to adjust the Black-Scholes model to account for dividends.

   S. N(d1) – X. e-rt. N(d2) is the actual model C.

   In (S/x) + (r + σ2/2 × t))/σ, with d1. − t

   Using d1 (In (S/x) + (r-y + σ2/2 × t))/σ, the adjusted model C is equal to S. e-yt N(d1) – X. e-rt. N(d2)

   where "y" is the dividend yield determined by dividing dividends by the asset's current value.

5.7 Summary

Options are financial derivatives which provides the right (and not the obligation) to the purchaser of the option to buy/sell an underlying asset at a given price and time. As a type of derivative, options derive their

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value from the underlying asset. They are frequently employed for both market speculation and risk management. Financial derivatives' option pricing is a key feature that enables investors to protect themselves against market risks. A common technique for pricing options is the binomial option-pricing model, which is based on the assumption of continuous volatility and the creation of a binomial tree for option pricing. The model makes it possible to calculate option prices, including call and put option pricing, making it a crucial tool for investors trying to make educated portfolio selections.

The binomial model does, however, have certain drawbacks, including the assumption of continuous volatility and the challenge of effectively simulating real-world circumstances. Investors may choose how to use the model to their investing plans by being aware of the model's advantages and disadvantages.

The BSM is a mathematical equation that assesses the theoretical value of pricing bonds, stocks, etc. based on six primary variables

Formula:

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

$d_1 - (I_n(S/x) + (r + \sigma^2/2 \times t))/\ \sigma\ .\ \sqrt{t}$

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

The BSM model assumes that markets work well. Trading is done at all the time. Returns follow Log-normal distribution. Securities underlying option pay no dividends or other cash flows. Risk-free interest rate is known & there are no taxes or transaction costs

5.8 Answers to In-Text Questions

1. *(b)* The underlying asset's price can only move up or down by a fixed percentage each time period

2. True

5.9 Self-Assessment Questions

1. How do option prices impact financial derivatives, and how can an understanding of option pricing help mitigate risks in financial markets?
2. What are the assumptions behind the binomial option-pricing model, and how do these assumptions impact the accuracy of option prices?
3. Suppose you hold a put option on a stock with a strike price of Rs. 120. The current price of the underlying stock is Rs. 100, and the option has a delta of -0.5. You want to hedge your position by trading the underlying stock. What is the hedge ratio, and how many units of the stock should you trade to fully hedge your position in the option?
4. How can we construct a binomial tree for option pricing, and how does this tree help us understand the underlying asset's potential price movements?
5. Can you explain the difference between a call and a put option, and how do we calculate their prices using the binomial model?
6. What are the limitations of the binomial option-pricing model, and how can we address these limitations when making investment decisions?
7. A stock has a volatility of 25% and its current price is Rs. 60. Calculate the up and down factors if the stock price can either go up by 10% or go down by 5% in one year.
8. A stock has a volatility of 30% and its current price is Rs. 80. Calculate the up and down factors if the stock price can either go up by 15% or go down by 10% in six months.
9. Suppose a stock has a current price of Rs. 100. In the next year, the stock price can either go up by 20% or go down by 10%. Draw the binomial tree for this scenario with two-time steps.

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5.10 References

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Glossary

Arbitrage: Arbitrage is the act of buying and selling the same asset at the same time in two or more places in order to lower the risk involved.

Basis: Basis is the difference between the prices of the present and the future.

Binomial Option-pricing Model: A widely used method for pricing options, based on the assumption of constant volatility and the construction of a binomial tree for option pricing.

Binomial Tree: A graphical representation of the possible outcomes of an option at each point in time.

Caps and Floor: There are two types of derivatives called caps and floors. They set maximum (caps) or minimum (floors) interest rates to protect against changes in interest rates.

CDS: Credit derivatives are tools like credit default swaps and collateralized debt obligations (CDOs) that are used to control credit risk.

Constant Volatility: An assumption made in the binomial model that the volatility of the underlying asset remains constant.

Cost of Carry: The "Cost of Carry" is the sum of the cost of storing the object, any interest paid on it, and the amount of money made from it.

Cross Hedge: A cross hedge occurs when a futures contract is used to hedge against price movements in a related but not identical asset.

Delivery Price: It refers to the set price for the underlying object that the forward contract will settle at some point in the future.

Derivative: A financial instrument whose value is derived from an underlying asset.

Financial Intermediaries: Institutions that help savers and borrowers move money around in the financial markets are called financial intermediaries.

Foreign Exchange Markets: Foreign Exchange Markets are places where people can buy and sell different currencies.

Hedge Ratio: The futures position to cash market position ratio is known as the.

Hedge: An investment that is bought against another investment in order to make up for any loss in the first one.

Hedging: A strategy used to minimize or offset potential losses by taking an opposite position in another asset.

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Long Hedge: A long hedge involves buying futures contracts to protect against a potential increase in the price of an underlying asset that you own.

Market Risks: The potential for losses due to changes in market conditions or unexpected events.

Money Markets: Money markets are places where people can borrow and give money for short periods of time. Usually, they use low-risk financial instruments.

Option Pricing: The process of determining the fair worth of an option contract.

Short Hedge: A short hedge involves selling futures contracts to hedge against a potential decrease in the price of an underlying asset that you plan to sell in the future.

Short Position: When party agrees to sell the base assets at a certain price and date. The person has the right to give the base asset at some point in the future.

Speculating: A strategy used to profit from market movements by taking a position in an asset.

Spot price: The price of a base asset on the market right now is called its spot price.

Stock Markets: Stock markets are places where people can buy and sell shares of companies that are open to the public.

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