

Chapter-12 Options and Greeks

Certificate in Risk Management

**Options – Greeks &
Risk Management**

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Chapter – 12 Options and Greeks

Introduction

This chapter is an introduction to methods used in dealing with optionality in financial instruments. Nowadays, many investors' portfolios include investments such as mutual funds, stocks and bonds. But the variety of securities you have at your disposal does not end there. Options are the result of unrelenting search for better instruments. Options belong to a class of instruments referred to as "Derivatives because they derive their value from an underlying asset. The speculative nature of options may not fit many investors' style. But, before deciding whether to invest or not to invest in options, one should understand them. Without knowledge about options investors would not only forfeit having another item in their investing toolbox but also lose insight into the workings of some of the world's largest corporations. Whether it is to hedge the risk of foreign-exchange transactions or to give employees ownership in the form of stock options, most multi-nationals today use options in some form or another. This session will introduce you to the fundamentals of options.

Learning Objective



- Learning of Basics of Options
- Understand Options: Definition and Notation
- Types of Options.
- Options as an investment instrument.
- Different Tools for Options
- Get to know about Black Scholes options pricing model.
- Learning of The Greeks
- Uses of Greeks

12.1 Options

An Option is a contract in which the seller of the contract grants the buyer, the right to purchase from the seller a designated instrument or an asset at a specific price which is agreed upon at the time of entering into the contract. Options can also be defined as **contracts** which provide the holder the **right to buy or sell** a specified quantity of an underlying asset at a fixed price on or before the expiration date. The underlying assets on options include stocks (equity), stock indices, commodities, foreign exchange or futures, which are agreed to be traded at a future date at a fixed price. These are called stock options, index options, commodity options, currency options and futures options.

Options enable the investor to adjust his position according to any situation that arises in the market. According to the movements in the market the options allow investors to use them for hedging against any risk and also to speculate about the future market movements. Though options are versatile securities they can be extremely risky and complex as well.



In the trading of the options the option buyer acquires a right but has no obligation to buy or sell, while the option seller takes on an obligation. It is the buyer's choice to exercise the acquired right while it is not an obligation for him to do so; but when the option is exercised, the seller has to honor it as he has the obligation to fulfill.

An option is different from other derivatives in that it provides a downside protection against risk and also an upside benefit from favorable movements in the underlying asset prices.

Types of Options

i. A Call option

A call option gives the holder the right to buy an asset at a specific price within a specific period of time in future. Investors invest in call option expecting that the future price of the underlying asset in the market will increase before the option expires.

- A call option gives the buyer of the option the right to buy the underlying asset at a fixed price (strike price or K) at any time prior to the expiration date of the option.
The buyer pays a price for this right.

- At expiration,
 - If the value of the underlying asset (S) > Strike Price(K)
 - Buyer makes the difference: $S - K$
 - If the value of the underlying asset (S) < Strike Price (K)
 - Buyer does not exercise
- the value of a call increases as the value of the underlying asset increases
- the value of a call decreases as the value of the underlying asset decreases

ii. A Put option

A put option gives the holder the right to sell an asset at a specific price within a specific period of time in future. Investors in the put option expect the future market price of the underlying asset to fall before the option expires to gain the profits of investing in the option.

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- The TCS logo consists of a stylized 'T' icon followed by the company name 'TATA CONSULTANCY SERVICES' in a blue, sans-serif font.
- Put option gives the buyer of the option the right to sell the underlying asset at a fixed price at any time prior to the expiration date of the option. The buyer pays a price for this right.
 - At expiration,
 - If the value of the underlying asset (S) < Strike Price(K)
 - Buyer makes the difference: $K - S$
 - If the value of the underlying asset (S) > Strike Price (K)
 - Buyer does not exercise
 - the value of a put decreases as the value of the underlying asset increases
 - the value of a put increases as the value of the underlying asset decreases

iii. Long-Term Options

These are options with holding times of one, two or many years and may be attractive investment options for long-term investors or for companies to raise funds for investment in long-term projects. These options are called long-term equity anticipation

securities (LEAPS). LEAPS are identical to regular options as they also provide opportunities to control and manage risk. The only difference is that, LEAPS are options with longer periods of time. LEAPS are available on most widely held issues and are not available on all stocks.

Warrants are also long-term options with life of five years and above and are issued by companies and financial institutions. Some may also be traded on stock exchanges. These do not carry dividend payments and have no initial service costs.

iv. Exotic Options

The simple calls and puts which have already been discussed are also referred to as plain vanilla options. There are many types and variations of options and all have some special features in them. Options which are more complicated than the standard American or European options are referred to as Exotic options. These are completely different products with optionality as an embedded feature in them. Most of them are traded in the over-the-counter (OTC) market and are designed by financial institutions to meet specific requirements of the clients. Examples of such specific needs are yield enhancements or disaster insurances.

Types of exotic options: Asian options, Barrier options, Bermudan options, Binary options, Chooser options, Compound Options, Forward Start Options, Flex options, Look back options, Rainbow options, Exchange options, Home-made Artificial options etc.

Different exercise ways of Options

There are mainly three types of exercise styles of options which are prominently traded in the market. These are:

- European style options which mean the option can only be exercised on the expiry day.
- American style options which mean the option can be exercised at any time prior to the expiry.
- Bermudan options have a series of dates on which the option can be exercised.

The distinction between American, Bermudan and European options has nothing to do with geographic location.

Characteristics of an Option

- **Buyer (Holder)** - The owner of the option contract.
- **Premium** - The premium is the price of the option which is arrived at by the negotiation between the taker and the writer of the option. Option premiums are quoted on a cents per share basis. To calculate the full premium payable for a standard size option contract, multiply the quoted premium by the number of shares per contract, usually 100.
- **Exercise** - To exercise the option means to call upon the right granted in terms of the option. The buyer (holder) will be the party exercising the option.
- **Strike price/Exercise price (Rate)** - This is the price (rate) at which the buyer (holder) of the option is entitled to either buy or sell the underlying currency. The strike price is determined at the time the option is purchased.
- **Expiry/Expiration date** - The final date at which the option may be exercised in terms of the option contract that is the day on which the option expires.
- **Contract size** - An option contract size is standardized at 100 underlying shares. That means, 1 option contract represents 100 underlying shares. This may change if there is an adjustment such as a new issue or a reorganization of capital in the underlying share. In the case of index options, contract value is fixed at a certain number of dollars per index point (for example, \$10 per index point). The size of the contract is equal to the index level x the dollar value per index point (for example, for an index at 4,500 points, 1 contract would be $4,500 \times \$10 = \$45,000$).

Risks associated with Options

The risks that are unique to options affect both the holder and the writer of the option.

1. **Market risks-** The market value of options is affected by a range of factors. They may fall in price or become worthless on or before expiry. Changes in the price of the underlying may result in changes to the price of an option, but the change can sometimes be in a different direction or of a different magnitude to the change in the price of the underlying.
2. **Options are a wasting asset -** Options have an expiry date and therefore a limited life. An option's time value erodes over its life and this accelerates as an option nears expiry. It is important to assess whether the options selected have sufficient time to expiry for your view to be realized.
3. **Effect of 'Leverage' or 'Gearing' -** The initial outlay of capital may be small relative to the total contract value with the result that options transactions are 'leveraged' or 'geared'. A relatively small market movement may have a proportionately larger impact on the value of the contract. This may work against you as well as for you. The use of leverage can lead to large losses as well as large gains.

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4. **Options writers face potentially unlimited losses -** Writing (selling) options may entail considerably greater risk than taking options. The premium received by the writer (seller) is fixed and limited; however the writer may incur losses greater than that amount. The writer who does not own the underlying shares or does not have offsetting positions potentially faces unlimited losses.
5. **Liquidity and pricing relationships -** Market conditions (for example, lack of liquidity) may increase the risk of loss by making it difficult to effect transactions or close out existing positions. Normal pricing relationships may not exist in certain circumstances, for example, in periods of high buying or selling pressure, high market volatility or lack of liquidity in the underlying security.

12.2 Pricing an Option and affecting factors

Option Price is the amount paid by the option buyer to the option seller. This option price is also termed as Premium. This option price or premium depends to a larger extent on the demand and supply of the underlying stock trading in any options contract. The price of the option is impacted by two factors: time value of the option and the volatility of the option.

The price of the option increases as the time to expiration increases because this will increase the time value of the option, similarly the prices of options increase with increase in the volatility. The present market price of the underlying is an indicator of the future price.

Option Price is further classified in to two categories. They are:

- Intrinsic Value
- Time Value

Intrinsic Value:

Intrinsic value is the difference between the exercise price of the option and the market price of the underlying shares at any given time. Intrinsic Value, as discussed in previous chapters can be dealt separately for both call and put options.

Intrinsic Value for a Call Option is

$$\text{Max } [(S-D), 0]$$

S – Stock Price at the time of expiration

D – Delivery Price

Therefore, intrinsic value for a call option is the difference between the stock price at the time of expiration and the options strike price. If the stock price at the time of expiration is lesser than the delivery price, then the intrinsic value will become zero.

Similarly, intrinsic value for a Put Option is

$$\text{Max } [(D-S), 0]$$

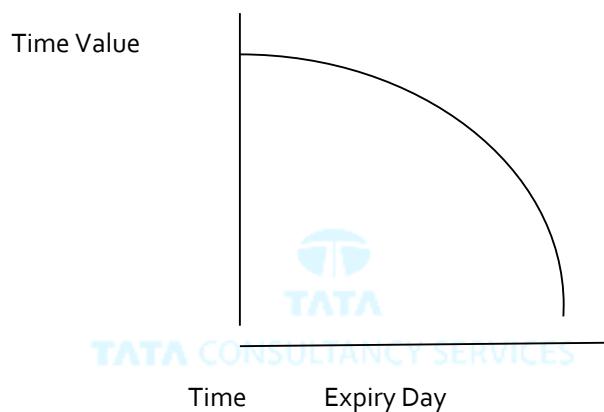
S – Stock Price at the time of expiration

D – Delivery Price

Therefore, intrinsic value for a put option is the difference between the option strike price and the price of the stock at the time of expiration. If the stock price at the time of expiration is higher than the option strike price then the intrinsic value of a put option is zero.

Time Value:

Time value represents the amount you are prepared to pay for the possibility that the Market might move in your favor during the life of the option. Time value will vary with in-the-money, at-the-money and out-of-the-money options and is greatest for at-the-money options.



As time draws closer to expiry and the opportunities for the option to become profitable decline, the time value declines. This erosion of option value is called time decay. Time value does not decay at a constant rate, but becomes more rapid towards expiry.

i. Binomial Options Pricing Model (BOPM)

The Binomial or binomial tree formulation was given by John Cox, Stephen Ross and Mark Rubinstein.

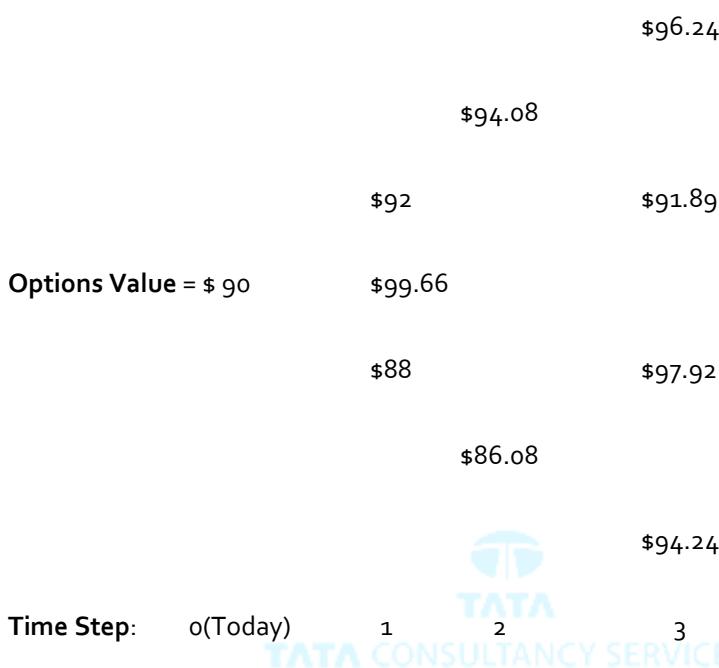
Basic "binomial model"

- Assume two periods and two possible values for stock price.
- Construct portfolio (long stock & short calls) that is perfectly hedged.
- Riskless hedge portfolio must earn the risk-less rate. Find implied call price.
- Price put options from put-call parity $c-p = S_0 - K e^{-rT} - D$
- Discrete states and discrete time (The number of possible stock prices and time steps are both finite)

This method is applicable even for American options, and is widely used for that reason.

Binomial model based on replication and arbitrage

A simplified example of a binomial tree looks like this:



For example, since it provides a stream of valuations for a derivative for each node in a span of time, it is useful for valuing derivatives such as American options which allow the owner to exercise the option at any point in time until expiration (unlike European options which are exercisable only at expiration).

Both the binomial model and the Black and Scholes model do not make any assumptions about the probability of the interest rates rising or falling. The Binomial model assumes that the writer of the option would hedge his position in such a way that the movement of the interest rates does not matter.

Hedging is mostly done through the purchase of forwards that would cover the exposure of the writer. For example, if the writer sold a call option, he might have to sell the underlying in case the rates rise, therefore he would enter into a forward (at the time of entering into the option itself) so that he can deliver the underlying. Binomial method gives an estimate of how many forwards to buy.

ii. Black and Scholes Model for Option Pricing

The only element of the option contract that keeps changing is the premium because it is market determined. Calculating the premium for the option is a specialized job and requires the skills of calculating the risk associated to a very accurate level. The factors that go into the calculation of the premium are the asset's strike price, its spot price, the time to expiration. Other factors used for the calculation of the option price include historical volatility of the asset, future volatility estimates and current interest rates.

- The version of the model presented by Black and Scholes was designed to value European options, which were dividend-protected.
- The Black-Scholes model applies when the limiting distribution is the normal distribution and explicitly assumes that the price process is continuous and that there are no jumps in asset prices.
- Continuous states (stock price can be anything between 0 and ∞) and continuous time (time goes continuously)
- It acknowledges that the option price is purely a function of the volatility of the stock's price (the higher the volatility the higher the premium on the option).



Its strength lies in that no assumptions are made about the movement of the interest rates during the period till the option's maturity. It is not required to know the return on equity or any capital appreciation figures to determine the future value of the stock, which in turn determines the value of the option.

The fair market value of a call option can be calculated by using the following formula:

$$C = S N(d_1) - K e^{(-rt)} N(d_2)$$

C = Theoretical call premium
 S = Current Stock price
 t = time until option expiration
 K = option striking price
 r = risk-free interest rate
 N = Cumulative standard normal distribution
 e = exponential term (2.7183)

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

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

s = standard deviation of stock returns
 ln = natural logarithm

For a put option, the formula is just reversed.

The weights for costs and benefits are dependent on the factors that affect the price\ of the option. The maximum weight is one, and the minimum is zero, therefore,

Maximum price for a call option = Current market price of the underlying.

Maximum price of the put option = Strike price of the option

Factors affecting the pricing of Options

Below are the various factors which affect the price of options. They are:

- The current stock price, S
- The Delivery/Strike Price, D
- The volatility of the stock Price, v
- The risk free interest rate, r
- Maturity/ Expiration Time, T
- Dividends expected during the life of the option



Variable	European Call	European Put	American Call	American Put
Current Stock Price	+	-	+	-
Strike/Delivery Price	-	+	-	+
Volatility of the Stock Price	+	+	+	+
Risk Free Interest Rate	+	-	+	-
Maturity/Expiration time T	?	?	+	+
Future Dividends	-	+	-	+

Table 10.1 Glimpse of the effect of variables on option prices

'+' indicates that there is a direct relationship between the variable and the price of a call/put option and

'-' indicates that there is an indirect relationship between the variable and the price of a call/put option

The above table gives a bird's eye view on the various factors which affect the price of options.

12.3 Greeks

Greeks measure the sensitivity of options to the various market factors. These indicators are called Greeks because they are denoted by the alphabet of that language. Greeks act as risk measures, which indicate the exposure of individual options to the market factors

The Greeks are:

i. Delta

Delta measures the change in the option premium expected from a small change in the stock price of the underlying asset.



$$\Delta = \frac{\partial (\text{Option price value})}{\partial (\text{Spot price})} = \frac{\text{Change in Option price}}{\text{Change in Spot Price}}$$

The value of delta varies between 0 and 1. For Deep in-the-money options, the value of delta approaches one, for deep out-of-money options the value approaches 0. For at-the-money options, delta is approximately 0.5.

Put options have a negative delta because they are inversely correlated with the prices of the underlying asset. As the price of the underlying asset falls, the premium on the put option increases (because the payoff from the put option increases). Delta also tends to increase as the option approaches maturity for at-the-money options.

ii. Gamma

The Gamma of any option is the rate of the change of the option's delta with respect to the price of the underlying stock. Gamma is the second order derivative of the option price with respect to the price of the underlying stock.

$$\Gamma = \frac{\partial^2 (\text{Option Value})}{\partial (\text{Spot Price})^2}$$

Gamma is the least for options that are deep out-of-money; and it increases, as the option becomes more in-the-money. Like delta, gamma is negative for all short options.

iii. Vega

Vega measures the sensitivity of an option price to changes in the volatility of the underlying. It gives the approximation of how much the option price will change if the volatility in the market changes

$$\Lambda = \frac{\partial (\text{Option Value})}{\partial (\text{Volatility})}$$

Long positions in options (buying calls or puts) benefit from increasing volatility because volatility increases the chances that the option will be in-the-money in the future. Vega can increase or decrease in a different way from the actual prices, because the implied volatility is expected volatility. Vega falls when the option approaches its expiry as volatility in prices can have little effect then.

iv. Rho (ρ)

It measures the sensitivity of option price to the changes in the interest rate. Long positions in calls benefit from increasing interest rates (because the underlying asset grows at a higher rate, increasing the chances of exercise of the option). Shorts on calls are negatively

impacted. Similarly shorts on puts are benefited and longs on puts are affected because the underlying grows at a faster rate, decreasing the chance of exercise.

v. Theta

It is also called 'Time Value Decay' or 'Time Decay', it gives the measure of how sensitive is the option price to the change in expiration time. Since passing of time is a given in any condition, theta is sometimes not considered a risk factor. Theta gives a measure of the time value of the option; therefore theta is highest for an option that is at the money (since time value is maximum).

$$\theta = \frac{\partial(\text{Option Value})}{\partial(\text{Change in time})}$$

Benefits of Options



1. **Hedging** - By using options, investor would be able to restrict his downside risk while enjoying the full upside benefits in a cost-effective way. Options let the investor have the choice either to exercise the option if it's making profit or to let it simply expire if it is out of the money. Thus options hedge the investors against the downside risk of the market movements.
2. **Speculation** - Though options are considered to be risky, if one knows about the movements of the market prices then options can turn out to be the business of profit. By assessing the market price movements and the direction of the stock's movement one can invest in options and can use the options for speculative purposes.
3. **Combined Optimal portfolio** - Options can be combined with other fixed income securities, thus creating a portfolio with characteristics of a fixed income security. Lending and borrowing at more attractive rates will be possible on such a portfolio.
4. **Diversification** - Options can allow you to build a diversified portfolio for a lower initial outlay than purchasing shares directly.

5. **Leverage** - Leverage provides the potential to make a higher return from a smaller initial outlay than investing directly. However, leverage usually involves more risks than a direct investment in the underlying shares. Trading in options can allow you to benefit from a change in the price of the share without having to pay the full price of the share.



Summary

- Options are derivatives that give the holder of an option the right (but not the obligation) to buy (or sell) an underlying asset at a future date at a price fixed on the current date.
- A **Call** option gives the holder the right to buy an asset at a specific price and within a specific period of time in future. Investors invest in call option expecting that the future price of the underlying asset in the market will increase before the option expires.
- A **Put** option gives the holder the right to sell an asset at a specific price and within a specific period of time in future. Investors in the put option expect the future market price of the underlying asset to fall before the option expires to gain the profits of investing in the option.
- There are four types of participants in options markets depending on the position they take: Buyers of calls, Sellers of calls, and Buyers of puts and Sellers of puts.
- The option derivatives launched by the exchanges have certain tenures and they allow to buy call and put options for only pre-specified times during the year.
- The value of an option consists of two components, its **intrinsic value** and its **time value**. Time value is simply the difference between option value and intrinsic value.
- The price of the option is impacted by two factors: time value of the option and the volatility of the option. The price of the option increases as the time to expiration increases because this will increase the time value of the option, similarly the prices of options increases with increase in the volatility.
- By using options, investor would be able to restrict his downside risk while enjoying the full upside benefits in a cost-effective way. Option let the investor to have the choice of either to exercise the option if it is making profit or to let it simply expire if it is out of the money.



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