Analysis of Option Prices Using Black Scholes Model

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ABSTRACT
The Black Scholes option pricing model is a financial mathematical equation used to determine the option Premium in order to calculate the theoretical price of an option to help the Option traders make smart decision. In this paper the Black Scholes Model is used to estimate the Option premium of different call and put options. The three different option chain selected in this paper are all Mid-Cap firms listed on the National Stock Exchange of India. The firms are Biocon Industries Ltd, Godrej Industries Ltd and Jindal Steel and Power Ltd. The study shows that the option premium calculated using Black Scholes model is less as compared to actual premium in the market leaving the options overpriced.
Keywords: Option, Black Scholes Option Pricing Model, Call, Put, Option Premium

INTRODUCTION

Black Scholes's Model is a financial mathematical model which is used to determine the Black Scholes equation in order to calculate the theoretical price of an option. It is used to calculate the option prices in case of an European Option (exercised only on its expiry unlike an American Option that can be exercised before or at the expiration date, thus providing more flexibility) by considering the underlying price, the strike price, the market volatility, time to expiration of the option, expected dividend rate and the market rate of interest. The Black Scholes model was developed by three economists – Fisher Black, Myron Sholes and Robert Merton, so it also known as Black Scholes Merton.

The Black Scholes Model makes certain assumptions while calculating the Option prices. These assumptions are-

- The Option is European Option.
- The model assumes no dividend is paid during the life of the option.
- Efficient Market(i.e. No prediction of Market movements)
- No Transaction cost involved in buying of the Options
- Returns on the Underlying are normally distributed
- This model assumes that risk free rate of return and the volatility remains constant.

An Option i.e. mentioned above is a derivatives contract that derives its value from an underlying asset. On purchase of an options contract, it gives the owner the right and not the obligation to either buy or sell the underlying assets. A call option gives the option buyer a right to buy and not an obligation to hold the underlying asset, whereas a put option gives the holder of the option a right to sell and not an obligation to sell the underlying asset. Option Traders use Black Scholes option pricing model in order to calculate the theoretical price of the options by calculating the call and the put premium and then adding it to the Spot Price. There are six

factors that affect this model - Spot price, days until expiration, strike price, Volatility Option Premium and Risk free interest rate.

Black Scholes Formula:

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

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

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

C = Call premium
S = Current stock price
t = Time until option exercise
K = Option striking price
r = Risk-free interest rate
N = Cumulative standard normal distribution
e = Exponential term

s = St. Deviation
ln = Natural Log

This formula takes into account certain important factors as –

1. Option Premium- It is an amount given by the Option Buyer to the Option Writer for the undertaking of the obligation to Buy/Sell the underlying asset without enjoying the right to reject the same.
2. Current Stock Price/Underlying Price- It is the current prevailing stock price of the underlying asset of the Options contract.
3. Time until expiration – The time until which the Options contract between the Option Buyer and the Option Writer will expire.
4. Strike Price - The price at which an Options trader bets as to whether the o=price of the underlying asset will go up or fall below the strike price.
5. Risk free interest rate – It is the interest rate of a risk free instrument in the market that is free from the market risks, In India it is generally the interest on a Treasury bill.
6. Volatility – The variation in the trading prices in the market over certain period of time.

Though the investor could invest in various options, but the assumption is being made that he is interested in options contract of a particular industry or sector.

REVIEW OF LITERATURE

1. (Sharma & Arora, 2015) tested the relevance of Black Scholes Model in the Indian Stock market for the Option prices by using the model to calculate the theoretical Option Prices using the equation and then comparing it with the actual values. All the necessary assumptions have been taken into consideration in this research as required by the model for option price calculation. The research concluded that the Black Scholes model values were not relevant to the market values of the stock options. The findings also showed that there is a need to explore other impacts on the pricing of the stock options than the Black Scholes Model.
2. (Nilakantan & Jain, 2014) Found in their study in the context of Indian Stock market that the Black-Scholes model suffers from various deficiencies. They concluded that modified B-S Model is not able to produce efficient results for NIFTY index option in case of At-the-money, Out-of the Money and Deep Out-of-the-Money options. In most of cases call options are under prices by the Black-Scholes model. The B&S Model under prices high volatility stock. It pays low reward for the stock that has high volatility.

3. (Shinde & Takale, 2012) This paper aims to study the option pricing using Black-Scholes model. It also gives a brief view about the required definitions and different derivations, which are useful for further development and also development of Black-Scholes partial differential equation. It not only explains the concepts in a theoretical manner but also helps us understand by obtaining the solution of Black-Scholes equation and represented it graphically by maple software. The paper uses European Option for expiration date and calculates the option prices using Stochastic Differential Equation, Black-Scholes Partial Differential Equation. And it also proves the relevance of the usefulness in financial sector, especially financial engineering. It concludes with the findings that call option prices change by varying parameters.
4. (Kumar & Agrawal, 2017) The Black-Scholes Model suffers from a pricing error at the deeper out-of-the money options, which is greater, compared at the near out-of-the-money options and this error increases as the volatility increases. The Black-Scholes model suffers from an error of mispricing options considerably and this error of mispricing increases as the moneyness and volatility increases. The Black-Scholes model overprices short-term options and under-prices long-term options. The Black-Scholes model exhibits pricing errors on several parameters. The Black-Scholes model under prices in-the money options and overprices out-of-the-money options. The pricing errors are comparatively lesser in the modified BS model compared to the present one. The Black-Scholes model suffers from various deficiencies. It was understood that the modified BS Model would not be able to produce efficient results for NIFTY index option in the case of At-the-money, Out-of the Money and Deep Out-of-the-Money options. The BS Model under prices stocks with high volatility and pays low reward for these stocks.

RESEARCH DESIGN

Statement of Problem -

The pricing of Options in the market is dependent on certain factors such as Spot price, Volatility etc. so it is difficult to estimate the Option prices. Black Scholes Option pricing model also has makes certain assumptions for the pricing of the option that makes It applicable to European Option pricing effectively. In this Paper the Black Scholes Model will be used to estimate the option premium in order to calculate the option prices to see whether the model is effective or not.

Sources of Data-

The data taken for the purpose of research paper is Secondary data. The Stock prices and the Option Chain are collected from the following websites:

- http://www.nseindia.com
- http://moneycontrol.com
- http://www.investopedia.com

Hypothesis-
We studied samples of both Call and Put options, where each sample consists of option values of certain different days.

The Black Scholes Model has been used for the pricing of the Options.

In order to find the significant difference between the model values and the actual values, we have formulated certain hypothesis-

Null Hypothesis (HO): There is no significant difference between Black Scholes values and the Actual market values.

Alternate Hypothesis (H1): There is significant difference between Black Scholes values and the Actual market values.

Data Analysis Tools
The tool used for data analysis in this paper is the Black Scholes Option Pricing Model-

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

This model is used to calculate The Value of A Call (C) using the normal distribution table (N) by taking the difference between the two parts.

The two parts of the model are –

1. The first part consists of $SN(d_1)$ which is the multiplication of the price by the change in the call premium in relation to change in underlying price. Where d_1 is calculated using:

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

- *In* – is the natural log
- *S* – Is the current stock price of the underlying asset
- *K* – It is the Strike price
- *r* – represents the Risk free interest rate
- σ - is the standard deviation i.e. is the volatility of the market inserted in the form of decimal in the formula
- *T* – Is the time until option exercise.

2. The second part is $N(d_2)Ke^{-rt}$ which is nothing but the present value of the exercise price discounted back to today at the risk free rate of return, sine Black Scholes uses the continuous discounting that's why it uses the exponential. Here d_2 is calculated using the formula:

$$d_2 = d_1 - \sigma\sqrt{T}.$$ Where,

- d_1 – is calculated above.
- σ - is the standard deviation i.e. is the volatility of the market inserted in the form of decimal in the formula
- T – Is the time until option exercise

Expected Outcome

The expected outcome of this research is to find the theoretical prices of the Option and the intrinsic value using the Black Scholes Model and compare with the Actual prices to find out whether this model holds good for the purpose of option pricing or not.

Limitations

The limitations of this paper are –

- This model is mainly used for pricing of European Options
- It assumes that there is no arbitrage opportunity and the market is 100% efficient
- It assumes that market volatility and the risk free rate of return remains constant.
- This Model ignores liquidity and brokerage charges.
- It assumes no dividend is paid thus ignoring the impact of it on the valuation.

Data Analysis and Interpretations

Black Scholes Model Calculation

1) **BIOCON Industries Ltd**

Biocon is Asia's premier biopharmaceutical company that is driven by the vision to make a difference to global healthcare through improved access to high quality, life-saving bio therapeutics by making them affordable for patients across the world.

Calculation of option valuation:

- Risk free rate = 6.98%
- Spot price= 679.80
- Expiration date= 27/09/2018
- Volatility= 13.57%

a) In the money:

From the above table we will assume our strike price as 660. Since the spot price is greater than the strike price, it would be considered as in the money.

Strike price = 660

Option Chain (Equity Derivatives)

Underlying Stock: BIOCON 679.80 As on Sep 21, 2018 15:30:30 IST

View Options Contracts for: Select Index OR Search for an underlying stock: GO Filter by: Strike Price: 660.00 Futures contracts

CALLS												PUTS									
Chart	OI	Chng in OI	Volume	IV	LTP	Net Chng	Bid Qty	Bid Price	Ask Price	Ask Qty	Expiry Date	Bid Qty	Bid Price	Ask Price	Ask Qty	Net Chng	LTP	IV	Volume	Chng in OI	OI	Chart
	197,100	-18,000	179	36.08	25.50	4.75	900	23.55	25.55	900	27SEP2018	900	4.90	6.00	900	-1.75	6.95	44.28	774	7,200	156,600	
	7,200	-	1	27.59	37.70	-1.30	3,600	34.35	-	-	25OCT2018	900	17.45	-	-	-2.05	19.45	37.82	3	2,700	3,600	
	-	-	-	-	-	-	-	-	-	-	29NOV2018	-	-	-	-	-	-	-	-	-	-	
Total	204,300		180																777		160,200	Total

As per the Black Scholes's model

- **call option premium = 20.36**
  The value of call option premium as per Black Scholes's model is less than that mentioned in the NSE i.e **25.55**, which means that the call option is overvalued.

- **put option premium = 0.06**
  The value of put option premium as per Black Scholes's model is less than that mentioned in the NSE i.e **6.00**, which means that the put option is overvalued.

b) Out the money:

From the above table, we will assume our strike price as 700. Since the spot price is less than the strike price, it would be considered as out the money.

Strike price= 700.00

Option Chain (Equity Derivatives)

Underlying Stock: BIOCON 679.80 As on Sep 21, 2018 15:30:30 IST

View Options Contracts for: Select Index OR Search for an underlying stock: GO Filter by: Strike Price: 700.00 Futures contracts

CALLS												PUTS									
Chart	OI	Chng in OI	Volume	IV	LTP	Net Chng	Bid Qty	Bid Price	Ask Price	Ask Qty	Expiry Date	Bid Qty	Bid Price	Ask Price	Ask Qty	Net Chng	LTP	IV	Volume	Chng in OI	OI	Chart
	688,500	36,000	3,286	41.71	7.10	1.20	900	7.05	7.40	900	27SEP2018	3,600	25.25	34.95	3,600	-0.75	30.65	55.82	19	2,700	11,700	
	38,700	6,300	47	34.51	22.50	5.00	900	22.00	28.95	1,800	25OCT2018	900	10.10	47.90	2,400	6.00	52.00	53.66	8	2,700	10,800	
Total	727,200		3,333																27		22,500	Total

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As per the Black Scholes's model value of

- **call option premium = 0.08**

The value of call option premium as per Black Scholes's model is less than that mentioned in the NSE i.e **7.40**, which means that the call option is overvalued.

- **put option premium = 19.75**

The value of put option premium as per Black Scholes's model is less than that mentioned in the NSE i.e **34.95**, which means that the put option is overvalued.

2) **Godrej Industries Ltd:**

Godrej Industries is one of the Godrej Group's holding companies. They deal in consumer goods, real estate, agriculture and gourmet retail through their subsidiary and associate companies, across 18 countries.

Calculation of option valuation:

- Risk free rate = 6.98%
- Spot price= 549.00
- Expiration date= 27/09/2018
- Volatility= 12.50%

a) In the money:

From the above table we will assume our strike price as 540. Since the spot price is greater than the strike price, it would be considered as in the money.

strike price = 540

Option Chain (Equity Derivatives) Underlying Stock: GODREJIND 549.00 As on Sep 21, 2018 15:30:30 IST

View Options Contracts for: Select Index OR Search for an underlying stock: GO Filter by: Strike Price: 540.00 Futures contracts

CALLS												PUTS									
Chart	OI	Chng in OI	Volume	IV	LTP	Net Chng	Bid Qty	Bid Price	Ask Price	Ask Qty	Expiry Date	Bid Qty	Bid Price	Ask Price	Ask Qty	Net Chng	LTP	IV	Volume	Chng in OI	OI	Chart
	4,500	4,500	3	22.90	12.50	-59.30	6,000	10.90	24.85	1,500	27SEP2018	3,000	6.55	15.00	1,500	10.60	13.80	65.86	13	-	10,500	
	-	-	-	-	-	-	-	-	-	-	25OCT2018	-	-	-	-	-	-	-	-	-	-	
Total	4,500		3																13		10,500	Total

As per the Black Scholes's model

- **call option premium = 9.11**

The value of call option premium as per Black Scholes's model is less than that mentioned in the NSE i.e **24.85**, which means that the call option is overvalued.

- **put option premium = 0.01**

The value of put option premium as per Black Scholes's model is less than that mentioned in the NSE i.e **15.00**, which means that the put option is overvalued.

b) Out the money:

From the above table, we will assume our strike price as 560. Since the spot price is less than the strike price, it would be considered as out the money.

Strike price= 560.00

Option Chain (Equity Derivatives)

Underlying Stock: GODREJIND 549.00 As on Sep 21, 2018 15:30:30 IST

View Options Contracts for: Select Index OR Search for an underlying stock: GO Filter by: Strike Price: 560.00 Futures contracts

CALLS												PUTS									
Chart	OI	Chng in OI	Volume	IV	LTP	Net Chng	Bid Qty	Bid Price	Ask Price	Ask Qty	Expiry Date	Bid Qty	Bid Price	Ask Price	Ask Qty	Net Chng	LTP	IV	Volume	Chng in OI	OI	Chart
	13,500	6,000	8	16.93	1.35	-10.15	1,500	1.55	[illegible]	1,500	27SEP2018	15,000	7.60	21.95	1,500	16.10	25.00	69.00	14	-7,500	21,000	
	-	-	-	-	-	-	1,500	2.50	-		25OCT2018	1,500	8.35			-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	40.00	3,000	29NOV2018	-	-	-	-	-	-	-	-	-	-	
Total	13,500		8																14		21,000	Total

As per the Black Scholes's model value of

- **call option premium = 0.00**

The value of call option premium as per Black Scholes's model is less than that mentioned in the NSE i.e **5.90**, which means that the call option is overvalued.

- **put option premium = 10.89**

The value of put option premium as per Black Scholes's model is less than that mentioned in the NSE i.e **21.95**, which means that the put option is overvalued.

3) Jindal Steel & Power Limited

JSPL is an industrial powerhouse with a dominant presence in steel, power, mining and infrastructure sectors. Part of the US $ 22 billion OP Jindal Group, the Company is continuously scaling its capacity utilisations and efficiencies to capture opportunities and use it to their advantage.

Calculation of option valuation:

- Risk free rate = 6.98%
- Spot price= 234.85
- Expiration date= 27/09/2018
- Volatility= 14.69%

a) In the money:

From the above table we will assume our strike price as 230. Since the spot price is greater than the strike price, it would be considered as in the money.

strike price = 230

Option Chain (Equity Derivatives)

Underlying Stock: JINDALSTEL 234.85 As on Sep 21, 2018 15:30:30 IST

View Options Contracts for: Select Index OR Search for an underlying stock: GO Filter by: Strike Price: 230.00 Futures contracts

CALLS												PUTS									
Chart	OI	Chng in OI	Volume	IV	LTP	Net Chng	Bid Qty	Bid Price	Ask Price	Ask Qty	Expiry Date	Bid Qty	Bid Price	Ask Price	Ask Qty	Net Chng	LTP	IV	Volume	Chng in OI	OI	Chart
	659,250	-355,500	1,080	44.00	8.25	-0.25	4,500	8.25	8.50	6,750	27SEP2018	4,500	3.60	3.90	2,250	-1.60	3.50	48.32	3,112	182,250	753,750	
	96,750	4,500	4	43.31	16.00	0.30	11,250	14.20	18.15	2,250	25OCT2018	2,250	10.10	12.60	2,250	-0.80	10.60	49.08	73	-29,250	67,500	
Total	756,000		1,084																3,185		821,250	Total

As per the Black Scholes's model

- **call option premium = 4.90**
  The value of call option premium as per Black Scholes's model is less than that mentioned in the NSE i.e **8.50**, which means that the call option is overvalued.

- **put option premium = 0.00**
  The value of put option premium as per Black Scholes's model is less than that mentioned in the NSE i.e **3.90**, which means that the put option is overvalued.

b) Out the money:

From the above table, we will assume our strike price as 240. Since the spot price is less than the strike price, it would be considered as out the money.

Strike price= 240.00

Option Chain (Equity Derivatives)

Underlying Stock: JINDALSTEL 234.85 As on Sep 21, 2018 15:30:30 IST

View Options Contracts for: Select Index OR Search for an underlying stock: GO Filter by: Strike Price: 240.00 Futures contracts

CALLS												PUTS									
Chart	OI	Chng in OI	Volume	IV	LTP	Net Chng	Bid Qty	Bid Price	Ask Price	Ask Qty	Expiry Date	Bid Qty	Bid Price	Ask Price	Ask Qty	Net Chng	LTP	IV	Volume	Chng in OI	OI	Chart
	1,734,750	-616,500	4,807	46.24	3.55	-0.85	2,250	3.50	3.60	2,250	27SEP2018	20,250	7.45	8.50	24,750	-1.75	8.40	47.06	2,026	177,750	596,250	
	254,250	-11,250	101	47.00	12.10	0.60	9,000	12.10	12.80	2,250	25OCT2018	4,500	7.25	22.00	22,500	-0.35	15.70	49.36	43	-6,750	303,750	
	2,250	-	-	-	18.50	-	-	-	-	-	29NOV2018	-	-	-	-	-	-	-	-	-	-	
Total	1,991,250		4,908																2,069		900,000	Total

As per the Black Scholes's model value of

- **call option premium = 0.00**

The value of call option premium as per Black Scholes's model is less than that mentioned in the NSE i.e **3.60**, which means that the call option is overvalued.

- **put option premium = 5.11**

The value of put option premium as per Black Scholes's model is less than that mentioned in the NSE i.e **8.50**, which means that the put option is overvalued.

CONCLUSION

The Black Scholes's Model allows the investor to make a smart decision by finding out whether the options have been overvalued or undervalued depending on which, the appropriate decision can be made. Thus it is finally concluded that the Null Hypothesis (Ho) is accepted as there is significant difference between Black Scholes Option Prices and the Actual Option prices.

Bibliography

- Kumar, R., & Agrawal, R. (2017). Empirical Investigation of the Black Scholes option pricing model with reference to NSE. *International Journal of BIRC Business Research(IJBBR)*.
- Nilakantan, N., & Jain, A. (2014). Option Pricing with Skewness and Kurtosis Adjustments. *Second International Conference on Global Business, Economice,Finace and Social Sciences.* Chennai: GB14.
- Sharma, M., & Arora, D. (2015). Study Of Relevence Of Black-ScholesModel in Indian Stock Option Market. *IJARIIE*, 324-334.
- Shinde, A., & Takale, K. (2012). Study of Black Scholes Model and its Application. *Procedia Engineering*, 270-279.
- Vohra, N., & Bagri, B. (2003). *FUTURES and OPTIONS.* New Delhi: Tata McGraw-Hill.