JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

The Black-Scholes Option Pricing Model and Its Application to the Indian Derivatives Markets - A Case Study of Selected NSE Stock Options

Rahul Pal

Research Scholar

Department of Commerce,

DDU Gorakhpur University, Gorakhpur

Dr. Maneesh Kumar

Assistant Professor

Department of Commerce,

DDU Gorakhpur University, Gorakhpur

Abstract

Option pricing is critical for both hedgers and speculators in the options market. A widely accepted option-pricing model is the Black-Scholes model. The Black Scholes Model is used in this paper to estimate the option premiums for various call and put options. This research investigates the relevance of the Black-Scholes model in the Indian derivatives market, focusing on select NSE stock options. The study demonstrates that the option premium estimated using the Black Scholes model is low compared to the actual premium in the market, leaving the options overpriced.

Keywords -: Option Pricing, Black- Scholes Model, Indian Derivatives Market, call and put options, option premiums

Introduction

In the derivatives market, option pricing is critical. Accurate option pricing removes the possibility of arbitrage. Hedgers and speculators mostly populate the derivatives market. In the case of stock market derivatives, speculation is more significant. Both speculators and hedgers are interested in pricing. The Binomial Model and the Black-Scholes Model are two significant models for option pricing. The Black-Scholes model is well-known. This research aims to determine the applicability of the Black Scholes model in the Indian derivatives market, focusing on select NSE stock options.

Review of Literature

According to **Fischer Black and Myron Scholes (1973),** real option prices deviate from the formula's anticipated values in predictable ways. Option purchasers pay prices that are consistently higher than the formula predicts. On the other hand, options writers get prices close to what the model predicts. The options market has high transaction costs, which option purchasers essentially pay. For options on low-risk stocks, the discrepancy between the price paid by option purchasers and the value supplied by the formula is bigger than for options on high-risk stocks.

When interest rates are stochastic, **J. Orlin Grabbe (1983)** investigated a set of inequality-equality requirements on rational pricing of foreign currency options and established accurate pricing formulae for European puts and calls. The assumption that relevant variables follow diffusion processes allows us to construct a riskless hedge that does not rely on wealth and, as a result, must have a zero return in equilibrium. The solution to the partial differential equation resulting from the development of this hedge is the European call option value. A put-to-call conversion equation that holds for FX options is used to extract the put option equations directly from the call equations. Finally, it was demonstrated that American calls are profitable for sufficiently high (low) spot rates compared to the exercise price.

David Chappell (1992) the mathematical skills necessary in the derivation and solution of the Black-Scholes model are relatively advanced, and many economists are unlikely to be conversant with them. When properly adjusted to provide an instantaneous rather than annual rate, the T-Bill rate or LIBOR may be used as a substitute for a risk-free rate of return. There are several methods for calculating the variance rate and standard deviation.

According to **Gurdip B, Charles C, and Zhiwu (1997)**, considering stochastic volatility is first-order relevant in enhancing the Black-Scholes formula, independent of performance yardstick. Each stochastic volatility model demands very improbable levels of volatility return correlation and volatility variation in order to reconcile the negative skewness and excess kurtosis implied in option pricing. S. McKenzie, D. Gerace, and Z. Zhu have all contributed to this project.

The Black-Scholes model is not the correct pricing tool in high volatility scenarios, according to **Ramazan G and Aslihan S (2003)**, especially for very deep out-of-the-money options. Feedforward networks give more accurate price estimates for deeper out-of-the-money options, manage to price for the out-of-the-money call, and put options with significantly more minor mistakes amid high volatility. Option pricing is a massive difficulty during periods of high volatility; therefore, this knowledge might be quite valuable for practitioners. The Black-Scholes pricing overestimates market prices for the deepest out-of-the-money options, while market prices are overestimated for the deeper and near out-of-the-money options. The Black-Scholes model's effectiveness in explaining observed market prices is dismal for the deepest out-of-the-money options.

According to **Subedar (2007)**, The Black Scholes model is fairly accurate. According to a comparison of qualitative regression models, the Black Scholes model is important at the 1% level in determining an option's likelihood. Each regression model's variables all show hints of economic relevance. The Black-Scholes factors are statistically significant, according to the findings obtained using the maximum likelihood technique. The importance of the Black-Scholes model under a logistic distribution is preferable to a lognormal distribution is also demonstrated by qualitative regression models. The statistical relevance of the Black-Scholes model is increased by indicating that the employment of a jump-diffusion strategy boosts the tail features of the lognormal distribution. In the second stage, the least-squares technique gives significance at the 1% level to assess the significance of qualitative regression models.

When the operators compute the volatility on which they assess the option, **Emilia Vasile and Dan Armeanu (2009)** take into account the moneyness of the option and the length up to the due term. The Black-Scholes model cannot be used in its original form since financial asset values do not follow log-normal distribution principles.

Shinde & Takale (2012) examined the Black-Scholes model for option pricing. Additionally, it provides a concise overview of the necessary definitions and derivations necessary for future development and the creation of the Black-Scholes partial differential equation. It teaches the topics theoretically and assists in their comprehension by deriving the solution to the Black-Scholes equation and visually representing it using maple software. The study uses European Options as the expiry date and estimates option prices using Stochastic Differential Equations and Black-Scholes Partial Differential Equations. Additionally, it demonstrates the utility of financial engineering in the financial industry. It closes by demonstrating how call option prices fluctuate in response to changes in various factors.

The GARCH (1,1) and Black Scholes models may be used to price index (call and put) and stock (put) options in the Indian stock market, according to **Shyam Lal Dev Pandey and Mihir Das (2013)**. The time effect affects the disparities between model and real pricing. For put and call options with lower volatility and fewer days to expiry, the GAARCH and BS Models produce superior outcomes. The model and market values do not vary significantly, according to the findings of the paired sample T-test.

Nilakantan & Jain (2014) revealed that the Black-Scholes model has some flaws when applied to the Indian stock market in their investigation. They determined that the modified B-S Model cannot produce efficient outcomes for NIFTY index options in In-the-Money, Out-of-the-Money, or Deep Out-of-the-Money. Call options are often undervalued according to the Black-Scholes model. The B&S Model underestimates the price of a stock with a high degree of volatility. It offers a poor return on a volatile stock.

Sharma & Arora (2015) examined the Black Scholes Model's applicability in the Indian stock market for Option pricing by utilising the model to construct theoretical Option prices using the equation and comparing them to real values. This study has considered all of the key assumptions needed by the model for calculating option prices. The analysis revealed that the Black Scholes model values were unrelated to the stock option market prices. Additionally, the results indicated that other influences on the price of stock options should be investigated in addition to the Black Scholes Model.

Kumar & Agrawal (2017) The Black-Scholes Model has a higher price error for deep out-of-the-money options than for close out-of-the-money options, and this error rises with increasing volatility. The Black-Scholes model has a significant inaccuracy in mispricing options, which grows as moneyness and volatility increase. In the Black-Scholes model, short-term options are overpriced, whereas long-term options are underpriced. Numerous parameters in the Black-Scholes model indicate price issues. The Black-Scholes model underestimates the value of in-the-money options and overestimates the value of out-of-the-money options. The improved BS model has far less price mistakes than the current one. Numerous flaws exist in the Black-Scholes model. It was anticipated that the updated BS Model would be incapable of producing efficient outcomes for NIFTY index options: At-the-Money, Out-of-the-Money, or Deep Out-of-the-Money. The BS Model undervalues equities with a high degree of volatility and pays a poor rate of return on them.

Objectives

1. To predict the volatility of the underlying stocks of select options.
2. This study aims to see how useful the Black-Scholes Option Pricing Model is.

Hypothesis

H_0: There is no significant difference between the model prices and market prices

$H\alpha$: There is a significant difference between the model prices and market prices.

Research Design

This study is applied research as it intends to find the relevance of the Black-Scholes Model in the Indian Derivative Market. The population study constitutes all the stock options traded on NSE. Deliberate Sampling method is applied. The sample comprises Asian Paints, Hero Moto Corp and Ambuja Cements Options. The historical data have been collected from the NSE website. The annualized volatility has been computed based on the daily closing prices of the calendar year. Interest on 6.51% Government securities 2021 is taken as a risk-free rate proxy. Actual option prices of January 2021 are compared with the model prices. Pricing is made in one-month advance for two strike prices, one at the In the Money (ITM) and another out of the Money (OTM).

Black-Scholes Option Pricing Model

Fischer Black and Myron Scholes created the Black-Scholes model for valuing stock options. It is a well-known options pricing model. Black-Scholes is a pricing model used to evaluate the fair price or theoretical value of a call or put option based on six factors: volatility, the kind of option, the underlying stock price, the time-period, the strike price and the risk-free rate. Because the quantum of speculation is more significant in stock market derivatives, appropriate option pricing removes the possibility of arbitrage.

The following is the formula for calculating options price:

The Black-Scholes Option Pricing Formula

$$c = SN(d_1) - Xe^{-rT}N(d_2)$$

$$p = Xe^{-rT}N(-d_2) - SN(-d_1).$$

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

$$d_2 = \frac{\ln(S/X) + (r-\sigma^2/2)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

S = Stock price.
X = Strike price of option.
r = Risk-free interest rate.
T = Time to expiration in years.
σ = Volatility of the relative price change of the underlying stock price.
$N(x)$ = The cumulative normal distribution function.

N represent a standard normal distribution with mean = 0 and standard deviation = 1

Assumptions of the Black Scholes Merton Model (BSM Model)

1. The Black-Scholes-Merton model implies that stock values follow a lognormal distribution because asset prices cannot go negative; they are constrained by zero.
2. Dividends are not paid: The BSM model assumes that equities do not pay dividends or interest.
3. The model assumes that options may be exercised only on their expiry or maturity dates. As a result, it does not price American choices appropriately. It is heavily traded in the European's options market.
4. Random walk: Because the stock market is unpredictable, it is thought to be in a condition of random walk, as market direction can never accurately forecast.
5. The BSM model assumes a frictionless market with no transaction costs, including fees and brokerage.
6. Risk-free interest rate: Interest rates are assumed to remain constant, resulting in a risk-free underlying asset.
7. Stock returns follow a normal distribution. This suggests that the market's volatility is consistent throughout time.
8. There is no arbitrage. It obviates the possibility of obtaining a risk-free profit.

Limitations

The following are the paper's limitations: –

- This methodology is most commonly used to price European Options.
- It assumes that there is no room for arbitrage and that the market is entirely efficient.
- It is predicated on the assumption that market volatility and the risk-free rate of return are constant.
- Liquidity and trading fees are not taken into account in this model.
- It is assumed that no dividend is paid; hence the influence on the valuation is ignored.

Data analysis and Interpretation

1) Asain Paints

Asian Paints Ltd produces paints for the Decorative, automotive, and Industrial markets. They also produce a variety of ancillaries such as primers, fillers, strainers, and other products. The firm has a cutting-edge supply chain system that connects its facilities across India.

Calculation of Option valuation -:

Risk free rate = 6.51%
Spot price= 3323.00
Expiration date= 27/01/2022
Volatility= 26.57%

a) In the money :

From the above table, we will assume our strike price as 3300. Since the spot price is greater than the strike price, it is considered in the money.

Strike Price = 3300

Underlying Index: ASIANPAINT 3,323.00 As on 19-Jan-2022 09:53:19 IST Terms of Use Best View Download (.csv)

	CALLS											PUTS										
	OI	CHNG IN OI	VOLUME	IV	LTP	CHNG	BID QTY	BID PRICE	ASK PRICE	ASK QTY	EXPIRY DATE	BID QTY	BID PRICE	ASK PRICE	ASK QTY	CHNG	LTP	IV	VOLUME	CHNG IN OI	OI	
	87	30	144	32.15	71.00	-30.80	150	71.20	72.20	150	27-Jan-2022	150	62.15	63.05	150	20.40	64.05	36.15	225	-13	166	
	-	-	-	-	-	-	-	-	197.50	150	24-Feb-2022	450	86.35	116.75	150	-	-	-	-	-	-	
Tot	87.00		144.00																225.00		166.00	

As per Black Scholes's model value of

- **Call option premium = 66.95**

As per Black Scholes's model, the value of call option premium is less than that mentioned in the NSE, i.e. **72.20**, which means that the call option is overvalued.

- **Put option premium = 39.25**

As per Black Scholes's model, the value of the put option premium is less than that mentioned in the NSE, i.e. **63.05**, which means that the put option is overvalued.

b) Out the money :

From the above table, we will assume our strike price as **3360**. Since the spot price is less than the strike price, it would be considered as out the money

Strike Price = 3360

Underlying Index: **ASIANPAINT 3,323.00** As on 19-Jan-2022 09:53:19 IST Terms of Use Best View Download (.csv)

	CALLS											PUTS										
	OI	CHNG IN OI	VOLUME	IV	LTP	CHNG	BID QTY	BID PRICE	ASK PRICE	ASK QTY	EXPIRY DATE	BID QTY	BID PRICE	ASK PRICE	ASK QTY	CHNG	LTP	IV	VOLUME	CHNG IN OI	OI	
	337	43	355	32.69	53.50	-26.60	300	53.55	54.40	150	27-Jan-2022	150	83.70	85.65	150	22.35	85.60	36.01	274	-54	264	
	13	-	-	-	-	-	150	93.15	144.80	150	24-Feb-2022	150	103.50	135.90	150	-	-	-	-	-	6	
Tot	350.00		355.00																274.00		270.00	

As per Black Scholes's model value of

- **Call option premium = 37.86**

As per Black Scholes's model, the value of call option premium is less than that mentioned in the NSE, i.e. **54.40**, which means that the call option is overvalued.

- **Put option premium = 70.07**

As per Black Scholes's model, the value of the put option premium is less than that mentioned in the NSE, i.e. **85.65**, which means that the put option is overvalued.

2) HEROMOTO CORP LIMITED

HeroMotoCorp is the largest two-wheeler motorbike manufacturer in the world. Hero Honda was the first manufacturer in India to offer four-stroke bikes, setting new benchmarks for fuel efficiency, pollution control, and quality. They have a well-developed distribution and service network that stretches across the country. CD Dawn, CD Deluxe, Pleasure, Splendor +, Splendor NXG,Passion PRO, Passion Plus, Super Splendor, Glamour, Glamour PGM FI, Achiever, CBZ Extreme, Hunk, and Karizma are among the company's products.

Calculation of Option valuation -:

Risk free rate = 6.51%

Spot price= 2709.00

Expiration date= 27/01/2022

Volatility= 23.43%

a) In the money:

From the above table, we will assume our strike price as **2700**. Since the spot price is greater than the strike price, it would be considered in-the-money.

Strike Price = 2700

Underlying Index: **HEROMOTOCO 2,709.00** As on 19-Jan-2022 10:27:50 IST Terms of Use Best View Download (.csv)

	CALLS											PUTS										
	OI	CHNG IN OI	VOLUME	IV	LTP	CHNG	BID QTY	BID PRICE	ASK PRICE	ASK QTY	EXPIRY DATE	BID QTY	BID PRICE	ASK PRICE	ASK QTY	CHNG	LTP	IV	VOLUME	CHNG IN OI	OI	
	1,068	-114	2,536	22.67	47.65	10.90	300	46.75	48.95	300	27-Jan-2022	300	34.05	35.30	300	11.55	35.00	26.93	568	20	546	
	244	12	74	16.81	82.00	18.15	300	75.15	81.75	300	24-Feb-2022	600	101.30	108.35	300	-16.40	102.35	36.58	24	2	197	
	-	-	-	-	-	-	300	70.00	-	-	31-Mar-2022	-	-	-	-	-	-	-	-	-	-	-
Tot	1,312.00		2,610.00																592.00		743.00	

As per Black Scholes's model value of

- **Call option premium =44.17**

As per Black Scholes's model, the value of call option premium is less than that mentioned in the NSE, i.e. **48.95**, which means that the call option is overvalued.

- **Put option premium = 31.32**

As per Black Scholes's model, the value of the put option premium is less than that mentioned in the NSE, i.e. **35.30**, which means that the put option is overvalued.

b) Out the money

From the above table, we will assume our strike price as **2740**. Since the spot price is less than the strike price, it would be considered as out the money

Strike Price = 2740

Underlying Index: **HEROMOTOCO 2,709.00** As on 19-Jan-2022 10:27:50 IST Terms of Use Best View Download (.csv)

	CALLS											PUTS										
	OI	CHNG IN OI	VOLUME	IV	LTP	CHNG	BID QTY	BID PRICE	ASK PRICE	ASK QTY	EXPIRY DATE	BID QTY	BID PRICE	ASK PRICE	ASK QTY	CHNG	LTP	IV	VOLUME	CHNG IN OI	OI	
	497	107	1,208	24.99	31.00	7.85	300	30.1[illegible]	31.45	300	27-Jan-2022	600	55.60	59.00	600	[illegible]	52.00	27.16	54	18	43	
	-	-	1	21.56	76.00	-51.70	900	52.45	78.55	300	24-Feb-2022	1,500	34.15	190.80	600	-	-	-	-	-	-	
Tot	497.00		1,209.00																54.00		43.00	

As per Black Scholes's model value of

- **Call option premium = 25.67**

As per Black Scholes's model, the value of call option premium is less than that mentioned in the NSE, i.e. **31.45**, which means that the call option is overvalued.

- **Put option premium = 52.76**

As per Black Scholes's model, the value of put option premium is less than that mentioned in the NSE, i.e. **55.60**, which means that the put option is overvalued.

3) Ambuja Cements

Ambuja Cements Ltd produces and sells cement and clinker locally and worldwide. They are the third biggest cement company in India. Bulk Cement Terminals are located at Surat, Panvel, Galle, and Cochin.

Calculation of Option valuation -:

Risk free rate = 6.51%

Spot price= 375.85

Expiration date= 27/01/2022

Volatility= 28.84%

a) In the money:

From the above table, we will assume our strike price as **370**. Since the spot price is greater than the strike price, it is considered in the money.

Strike Price = 370

Underlying Index: **AMBUJACEM 377.85** As on 19-Jan-2022 11:08:20 IST Terms of Use Best View Download (.csv)

	CALLS											PUTS										
	OI	CHNG IN OI	VOLUME	IV	LTP	CHNG	BID QTY	BID PRICE	ASK PRICE	ASK QTY	EXPIRY DATE	BID QTY	BID PRICE	ASK PRICE	ASK QTY	CHNG	LTP	IV	VOLUME	CHNG IN OI	OI	
	64	2	6	27.63	12.00	-7.70	1,500	12.25	13.65	1,500	27-Jan-2022	1,500	5.05	5.15	3,000	0.50	5.15	38.35	289	-9	194	
	-	-	-	-	-	-	6,000	14.25	30.15	6,000	24-Feb-2022	4,500	12.05	13.55	4,500	-5.05	12.40	-	12	8	8	
Tot	64.00		6.00																301.00		202.00	

As per Black Scholes's model value of

- **Call option premium = 10.04**

As per Black Scholes's model, the value of call option premium is less than that mentioned in the NSE, i.e. **13.65**, which means that the call option is overvalued.

- **Put option premium = 3.66**

As per Black Scholes's model, the value of put option premium is less than that mentioned in the NSE, i.e. **5.05,** which means that the put option is overvalued.

b) Out the money

From the above table, we will assume our strike price as **400**. Since the spot price is less than the strike price, it would be considered as out the money

Strike Price = 400

Underlying Index: **AMBUJACEM 377.85** As on 19-Jan-2022 11:08:20 IST   Terms of Use Best View Download (.csv)

	CALLS											PUTS									
	OI	CHNG IN OI	VOLUME	IV	LTP	CHNG	BID QTY	BID PRICE	ASK PRICE	ASK QTY	EXPIRY DATE	BID QTY	BID PRICE	ASK PRICE	ASK QTY	CHNG	LTP	IV	VOLUME	CHNG IN OI	OI
	1,210	-26	681	38.91	2.10	-1.25	1,500	2.10	2.25	7,500	27-Jan-2022	1,500	23.80	25.35	1,500	2.70	24.00	47.34	18	-	195
	101	35	106	37.93	10.45	-2.65	1,500	10.05	10.60	1,500	24-Feb-2022	3,000	29.95	32.40	1,500	1.10	30.35	40.31	12	5	14
	-	-	-	-	-	-	1,500	15.05	-	-	31-Mar-2022	-	-	-	-	-	-	-	-	-	-
Tot	1,311.00		787.00																30.00		209.00

As per Black Scholes's model value of

- **Call option premium = 0.57**

As per Black Scholes's model, the value of call option premium is less than that mentioned in the NSE, i.e. **2.25,** which means that the call option is overvalued.

- **Put option premium = 24.15**

As per Black Scholes's model, the value of the put option premium is less than that mentioned in the NSE, i.e. **25.35,** which means that the put option is overvalued.

Conclusion

The Black Scholes's Model enables the investor to make an informed selection by determining if the options are over-or under-valued and then making the proper decision. Thus, the Null Hypothesis (Ho) is eventually rejected since there is a significant difference between Black Scholes and Actual Option Prices. In the market, options may be under-or over-priced. Before going into an option contract, it is recommended to determine the predicted option price using the BSOP Model.

Bibliography

1. David Chappell, On the Derivation and Solution of the Black-Scholes Option Pricing Model: a Step-by-step Guide, Spoudai, July- December 1992, Vol.42, No. 3-4, pp. 193-207
2. Emilia Vasile and Dan Armeanu, Empirical Study on the Performances of Black-Scholes Model, Romanian Journal of Economic Forecasting, 2009, pp. 48-62.
3. Fischer Black and Myron Scholes, The Pricing of Options and Corporate Liabilities, The Journal of Political Economy, Vol. 81, No. 3, May - June 1973, pp.637-654.
4. Gurdip B, Charles C and Zhiwu, Empirical Performance of Alternative Options Pricing Models, The Journal of Finance, Vol. LII, No. 5, December 1997, pp. 2003-2049.
5. Hull, J., Options: Futures and other Derivatives, PHI.
6. J. OrlinGrabbe, The Pricing of Call and Put Options on Foreign Exchange, Journal of International Money and Finance,1983, pp. 239-253.
7. 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).
8. Nilakantan, N., & Jain, A. (2014). Option Pricing with Skewness and Kurtosis Adjustments. Second: International Conference on Global Business, Economics, Finance and Social Sciences. Chennai: GB14.
9. Sharma, M., & Arora, D. (2015). Study of Relevance of Black-ScholesModel in Indian Stock Option Market. IJARIIE, 324-334.
10. S. McKenzie, D. Gerace and Z. Subedar, An Empirical Investigation of the Black-Scholes Model: Evidence from the Australian Stock Exchange, Australasian Accounting Business and Finance, Volume 1, No. 4, 2007, pp. 71-82.
11. Shinde, A., & Takale, K. (2012). Study of Black Scholes Model and its Application. Procedia Engineering, 270-279.
12. Vohra, N., & Bagri, B. (2003). FUTURES and OPTIONS. New Delhi: Tata McGraw-Hill.
13. Retrived from URL : https://corporatefinanceinstitute.com/resources/knowledge/trading-investing/black-scholes-merton-model/