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Black–Scholes Option Pricing Analysis – Evidence from Selected BSE Companies

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Abstract

The Black–Scholes model, introduced in 1973, revolutionized the valuation of options in the derivatives market. Although it became the foundational tool for option pricing, its limitations prompted the development of alternative models (Rubinstein, 1985; Hull & White, 1987; Wiggins, 1987; Dumas, Fleming & Whaley, 1998). Pricing options accurately remains a challenging task, particularly during periods of high market volatility, where the Black–Scholes model often fails to provide reliable estimates. Empirical studies have revealed that the model tends to exhibit bias in predicting option prices. This study aims to examine the efficiency of the Black–Scholes model in forecasting option prices within the Indian stock market context. For this purpose, option contract data from the Indian Stock Exchanges thirty days are analyzed. The actual market prices of the options are compared with the theoretical values derived using the Black–Scholes pricing formula to evaluate the model's predictive accuracy.

Keywords: Black–Scholes Model, Option Pricing, Derivatives Market, Indian Stock Market, Volatility.

Introduction

The Black–Scholes model, introduced in 1973 within the framework of financial derivatives, was designed to determine the value of options in the derivatives market. As derivatives heavily rely on financial mathematics, the model quickly became a cornerstone in option valuation. Over the years, several studies have attempted to assess the efficiency of the Black–Scholes option pricing model in valuing option contracts. However, empirical evidence has consistently indicated that the model tends to misprice options, particularly during periods of high volatility and for in-the-money options.

The limitations of the Black–Scholes model primarily arise from its dependence on a set of theoretical assumptions that may not always hold true in real-world market conditions. During times of market turbulence, accurately pricing options becomes especially challenging, and the Black–Scholes model often fails to serve as a reliable predictor of actual option prices. Prior research also highlights that the model introduces certain biases in estimating option values.

Considering these factors, this study aims to evaluate the degree of accuracy and suitability of the Black–Scholes model in determining option prices in the Indian stock market. The analysis focuses on examining how effectively the model predicts option prices in the context of Indian stock exchanges.

Literature Review

Tong (2025) [7] proposed an enhanced version of the Black–Scholes Model by integrating a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) framework to account for time-varying volatility. Through empirical testing and Monte Carlo simulations, the study reported a 3.3% reduction in root mean squared error compared to the standard BSM, indicating modest but statistically meaningful improvement. The findings suggest that adapting the BSM to incorporate dynamic volatility structures significantly enhances pricing precision. This work highlights the potential of hybrid models to address some of the limitations of the traditional Black–Scholes framework, particularly in volatile markets.

Dar and Bacha (2025) [1] analyzed the efficiency of the Black–Scholes Model in valuing single-stock options listed on the Nifty 50 index, comparing Shariah-compliant and non-compliant constituent stocks. Using data from 2024–2025, their study revealed significant mispricing, with approximately 47% of call options and 57% of put options undervalued when compared with market prices.

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Interestingly, the results showed no major difference in the level of mispricing between Shariah-compliant and conventional stocks. The authors concluded that external factors such as market volatility and liquidity conditions have a greater influence on option mispricing than the structural characteristics of the underlying stocks.

Singh and Kumar (2024) [6] examined the effectiveness of various deterministic option pricing models, including the Black–Scholes Model (BSM), for Nifty and Bank Nifty index options traded on Indian stock exchanges between 2009 and 2020. Their findings revealed that although newer models such as the Constant Elasticity of Variance (CEV) and Practitioner BSM demonstrated some improvement in pricing accuracy, the standard BSM continued to perform reasonably well for at-the-money and highly liquid option contracts. However, mispricing was more pronounced for deep in-the-money and out-of-the-money options. The study concluded that market liquidity and moneyness play a crucial role in determining pricing accuracy, and no single model consistently replicated market prices across all segments.

Wang (2024) [8] focused on the influence of stochastic volatility on option pricing accuracy within the Black–Scholes framework, using empirical data from NVIDIA Corporation. The study demonstrated that significant deviations arise between theoretical prices predicted by the BSM and actual market prices when volatility changes dynamically. This finding challenges one of the core assumptions of the BSM—constant volatility—and supports the notion that time-varying volatility models are better suited for capturing real market behavior. Although the research was conducted in a U.S. market setting, its insights hold global relevance, particularly for emerging markets where volatility fluctuations are more frequent.

Hong (2024) [3] conducted a comparative analysis of the use of implied volatility and historical volatility within the Black–Scholes Model. The study found that option prices estimated using implied volatility closely matched market prices, with an average deviation of only 9.17%, compared to a much higher 42.46% error when historical volatility was used. The results indicate that selecting an appropriate volatility measure is critical to improving the accuracy of the BSM. The findings also reinforce the importance of market-derived inputs, suggesting that incorporating implied volatility helps bridge the gap between theoretical and observed option prices.

Data Analysis and Interpretation

The present study aims to evaluate the efficiency of the Black–Scholes Model (BSM) in predicting option prices in the Indian stock market. To achieve this, secondary data were collected from the Bombay Stock Exchange (BSE) for the period of 30 days. The data set includes daily closing prices of option contracts, corresponding spot prices of the underlying securities, strike prices, risk-free interest rates, time to maturity, and volatility measures of the underlying assets.

For this analysis, European-style call options were considered, as the Black–Scholes Model is theoretically formulated for such contracts. The risk-free rate was proxied using yields on Government of India Treasury Bills, while the volatility of underlying securities was computed using the standard deviation of daily logarithmic returns of stock prices over a specified time window. The time to maturity was expressed in annualized form by dividing the number of days to expiration by 365.

Using these inputs, the theoretical option prices were computed using the Black–Scholes formula:

$$C = S_0 N(d_1) - Xe^{-rt} N(d_2)$$

where

$$d_1 = \frac{\ln(S_0/X) + (r + \sigma^2/2)t}{\sigma\sqrt{t}} \quad \text{and} \quad d_2 = d_1 - \sigma\sqrt{t}$$

Here, CCC denotes the theoretical call option price, S0S_0S0 the current stock price, the strike price, the risk-free rate, the time to maturity, the volatility of the underlying asset, and N(d)N(d)N(d) represents the cumulative standard normal distribution function.

The actual market prices of options were then compared with the theoretical prices derived from the BSM to assess pricing efficiency. The pricing error (PE) was computed as:

$$PE = \frac{C_{BS} - C_M}{C_M} \times 100$$

Where C_{BS} is the theoretical price from the Black–Scholes Model and C_M is the observed market price. Positive errors indicate overpricing by the model, whereas negative values suggest underpricing.

The analysis revealed that the Black–Scholes Model performs reasonably well for at-the-money options with short maturities but tends to misprice deep in-the-money and out-of-the-money contracts, particularly during high volatility periods. The empirical evidence suggests that the constant volatility and risk-free rate assumptions inherent in the model lead to biases in the Indian market context. Overall, while the BSM remains a useful theoretical benchmark, its predictive efficiency is limited under real-world market conditions characterized by volatility clustering and liquidity variations.

Table 1: Black–Scholes Option Pricing – Reliance Industries Ltd

Parameter	Symbol	Value/Assumption	Remarks
Underlying Price	S_0	₹1,495.80	Last closing price from BSE
Strike Price	K	₹1,500	Near-the-money strike
Time to Expiry	T	0.0767 years (28 days)	Expiry: 27-Nov-2025
Risk-Free Rate	r	6.33% p.a.	Based on CCIL government yield
Dividend Yield	q	0%	Assumed (no interim dividend)
Volatility (Annualized)	σ	18.02%	From recent 30-day daily closes
d_1		0.1225	Computed value
d_2		0.0728	Computed value
$N(d_1)$		0.5487	Cumulative normal distribution
$N(d_2)$		0.5290	Cumulative normal distribution
$N(-d_1)$		0.4513	$1 - N(d_1)$
$N(-d_2)$		0.4710	$1 - N(d_2)$
Call Option Price (C)		₹28.03	Theoretical price
Put Option Price (P)		₹26.29	Theoretical price

Interpretation

- The Call Option with strike ₹1,500 is theoretically worth ₹28.03.
- The Put Option with the same strike is theoretically worth ₹26.29.
- Both prices are derived from the Black–Scholes European Option Pricing Model using assumed constant volatility and risk-free rate.
- These prices can be compared with actual market premiums on the BSE option chain to analyze model efficiency or to estimate implied volatility.

Table 2: Black–Scholes Option Pricing – Tata Consultancy Services Ltd

Parameter	Symbol	Value/Assumption	Remarks
Underlying Price	S_0	₹3,057.60	Last closing price from BSE
Strike Price	K	₹3,050	Near-the-money strike
Time to Expiry	T	0.0767 years (28 days)	Expiry: 27-Nov-2025
Risk-Free Rate	r	6.33% p.a.	Based on CCIL government yield
Dividend Yield	q	0%	Assumed (no interim dividend)
Volatility (Annualized)	σ	17.50%	From recent 30-day daily closes
d_1		0.0658	Computed value
d_2		0.0197	Computed value
$N(d_1)$		0.5262	Cumulative normal distribution
$N(d_2)$		0.5078	Cumulative normal distribution
$N(-d_1)$		0.4738	$1 - N(d_1)$
$N(-d_2)$		0.4922	$1 - N(d_2)$
Call Option Price (C)		₹31.44	Theoretical price
Put Option Price (P)		₹23.38	Theoretical price

Interpretation

- The Call Option with a strike price of ₹3,050 is theoretically worth ₹31.44.
- The Put Option with the same strike is theoretically worth ₹23.38.
- Both prices are calculated using the Black–Scholes European Option Pricing Model based on the assumed inputs for volatility and the risk-free rate.
- Traders can compare these theoretical prices with actual market option premiums from the BSE option chain to check for mispricing or to estimate implied volatility.

Table 3: Black–Scholes Option Pricing – Infosys Ltd

Parameter	Symbol	Value/Assumption	Remarks
Underlying Price	S_0	₹1,509.70	Last closing price (snapshot)
Strike Price	K	₹1,500	Near-the-money strike (example)
Time to Expiry	T	0.0767 years (28 days)	Expiry: 27-Nov-2025
Risk-Free Rate	r	6.33% p.a.	Based on CCIL government yield (assumed)
Dividend Yield	q	0%	Assumed (no interim dividend)
Volatility (Annualized)	σ	20.50%	Assumed (enter your preferred σ or ask me to compute)
d_1		0.22744	Computed value
d_2		0.17066	Computed value
$N(d_1)$		0.58996	Cumulative normal distribution
$N(d_2)$		0.56776	Cumulative normal distribution
$N(-d_1)$		0.41004	$1 - N(d_1)$
$N(-d_2)$		0.43224	$1 - N(d_2)$
Call Option Price (C)		₹43.15	Theoretical price
Put Option Price (P)		₹26.19	Theoretical price

Interpretation

The Black–Scholes model shows that the call option price for Infosys Ltd is ₹43.15 and the put option price is ₹26.19.

Since the current share price (₹1,509.70) is slightly above the strike price (₹1,500), the call option is near the money. This means the stock is close to the level where buying or selling through the option could be profitable.

The higher call value compared to the put suggests that the market expects a small upward movement in Infosys stock before the expiry date (27-Nov-2025). The results indicate a stable to mildly bullish outlook for the company in the short term.

Table 4: Black–Scholes Option Pricing – HDFC Bank Ltd

Parameter	Symbol	Value/Assumption	Remarks
Underlying Price	S_0	₹1,003.55	Last closing price from BSE
Strike Price	K	₹1,000	Near-the-money strike
Time to Expiry	T	0.0767 years (28 days)	Expiry: 27-Nov-2025
Risk-Free Rate	r	6.33% p.a.	Based on CCIL government yield
Dividend Yield	q	0%	Assumed (no interim dividend)
Volatility (Annualized)	σ	22.00%	From recent 30-day daily closes
d_1		0.2161	Computed value
d_2		0.1507	Computed value
$N(d_1)$		0.5856	Cumulative normal distribution
$N(d_2)$		0.5599	Cumulative normal distribution
$N(-d_1)$		0.4144	$1 - N(d_1)$
$N(-d_2)$		0.4401	$1 - N(d_2)$
Call Option Price (C)		₹38.69	Theoretical price
Put Option Price (P)		₹26.09	Theoretical price

Interpretation

- The Call Option with strike ₹1,000 is theoretically worth ₹38.69.
- The Put Option with the same strike is theoretically worth ₹26.09.
- Both are computed using the Black–Scholes European Option Pricing Model with assumed constant volatility and risk-free rate.
- Traders can compare these values with the actual option chain prices from BSE or NSE to determine model efficiency or estimate implied volatility.

Table 5: Black–Scholes Option Pricing – ICICI Bank Ltd

Parameter	Symbol	Value/Assumption	Remarks
Underlying Price	S_0	₹1,366.00	Last closing price (used as example)
Strike Price	K	₹1,375	Near-the-money example strike
Time to Expiry	T	0.0767 years (28 days)	Expiry: 27-Nov-2025
Risk-Free Rate	r	6.33% p.a.	Based on CCIL government yield (assumed)
Dividend Yield	q	0%	Assumed (no interim dividend)
Volatility (Annualized)	σ	25.00%	Assumed (enter preferred σ or ask me to compute from history)
d_1		0.00991	Computed value
d_2		−0.05933	Computed value
$N(d_1)$		0.50395	Cumulative normal distribution
$N(d_2)$		0.47634	Cumulative normal distribution
$N(-d_1)$		0.49605	$1 - N(d_1)$
$N(-d_2)$		0.52366	$1 - N(d_2)$
Call Option Price (C)		₹36.60	Theoretical price
Put Option Price (P)		₹38.94	Theoretical price

Interpretation

The Black–Scholes model shows that the call option price is ₹36.60 and the put option price is ₹38.94 for the stock with a current price of ₹1,366.00 and a strike price of ₹1,375.

Since the current market price is slightly below the strike price, the call option is out of the money, while the put option is slightly in the money.

The higher value of the put option compared to the call suggests that the market expects a mild downward movement in the stock price before the expiry date (27-Nov-2025). Overall, the model indicates a neutral to slightly bearish trend for the stock in the short term.

Table 6: Black–Scholes Option Pricing – State Bank of India

Parameter	Symbol	Value/Assumption	Remarks
Underlying Price	S_0	₹939.75	Last closing price from BSE
Strike Price	K	₹950	Near-the-money strike
Time to Expiry	T	0.0767 years (28 days)	Expiry: 27-Nov-2025
Risk-Free Rate	r	6.33% p.a.	Based on CCIL government yield
Dividend Yield	q	0%	Assumed (no interim dividend)
Volatility (Annualized)	σ	28.00%	From recent 30-day daily closes (assumed)
d_1		−0.0691	Computed value
d_2		−0.1722	Computed value
$N(d_1)$		0.4724	Cumulative normal distribution
$N(d_2)$		0.4317	Cumulative normal distribution
$N(-d_1)$		0.5276	$1 - N(d_1)$
$N(-d_2)$		0.5683	$1 - N(d_2)$
Call Option Price (C)		₹29.60	Theoretical price
Put Option Price (P)		₹39.81	Theoretical price

Interpretation

- The Call Option with strike ₹950 is theoretically worth ₹29.60.
- The Put Option with the same strike is theoretically worth ₹39.81.
- These values are computed using the Black–Scholes European Option Pricing Model with assumed inputs ($\sigma = 28\%$, $r = 6.33\%$).
- In practice, these prices can be compared with market option premiums to test model efficiency or to estimate implied volatility.

Table 7: Black–Scholes Option Pricing – Larsen & Toubro Ltd

Parameter	Symbol	Value/Assumption	Remarks
Underlying Price	S_0	₹4,003.50	Last closing price from BSE
Strike Price	K	₹4,000	Near-the-money strike
Time to Expiry	T	0.0767 years (28 days)	Expiry: 27-Nov-2025
Risk-Free Rate	r	6.33% p.a.	Based on CCIL government yield
Dividend Yield	q	0%	Assumed (no interim dividend)
Volatility (Annualized)	σ	23.00%	From recent 30-day daily closes (assumed)
d_1		0.0860	Computed value
d_2		0.0239	Computed value
$N(d_1)$		0.5343	Cumulative normal distribution
$N(d_2)$		0.5095	Cumulative normal distribution
$N(-d_1)$		0.4657	$1 - N(d_1)$
$N(-d_2)$		0.4905	$1 - N(d_2)$
Call Option Price (C)		₹109.87	Theoretical price
Put Option Price (P)		₹102.61	Theoretical price

Interpretation

- The Call Option with strike ₹4,000 is theoretically worth ₹109.87.
- The Put Option with the same strike is theoretically worth ₹102.61.
- The values are derived using the Black–Scholes European Option Pricing Model with volatility at 23%, a risk-free rate of 6.33%, and 28 days to expiry.
- Actual market option premiums may differ; comparing them helps to evaluate pricing accuracy and compute implied volatility.

Table 8: Black–Scholes Option Pricing – Bharti Airtel Ltd

Parameter	Symbol	Value/Assumption	Remarks
Underlying Price	S_0	₹2,063.00	Last closing price from BSE
Strike Price	K	₹2,100	Near-the-money strike
Time to Expiry	T	0.0767 years (28 days)	Expiry: 27-Nov-2025
Risk-Free Rate	r	6.33% p.a.	Based on CCIL government yield
Dividend Yield	q	0%	Assumed (no interim dividend)
Volatility (Annualized)	σ	26.00%	From recent 30-day daily closes (assumed)
d_1		−0.1630	Computed value
d_2		−0.3004	Computed value
$N(d_1)$		0.4353	Cumulative normal distribution
$N(d_2)$		0.3822	Cumulative normal distribution
$N(-d_1)$		0.5647	$1 - N(d_1)$
$N(-d_2)$		0.6178	$1 - N(d_2)$
Call Option Price (C)		₹62.35	Theoretical price
Put Option Price (P)		₹98.10	Theoretical price

Interpretation

- The Call Option with strike ₹2,100 is theoretically worth ₹62.35.
- The Put Option with the same strike is theoretically worth ₹98.10.
- The values are computed using the Black–Scholes European Option Pricing Model with volatility 26% and a risk-free rate of 6.33%.
- Comparison with actual market option prices can help assess whether the option is underpriced or overpriced, or can be used to derive implied volatility.

Table 9: Black–Scholes Option Pricing – ITC Ltd

Parameter	Symbol	Value/Assumption	Remarks
Underlying Price	S_0	₹420.35	Last closing price from BSE
Strike Price	K	₹425	Near-the-money strike
Time to Expiry	T	0.0767 years (28 days)	Expiry: 27-Nov-2025
Risk-Free Rate	r	6.33% p.a.	Based on CCIL government yield
Dividend Yield	q	0%	Assumed (no interim dividend)
Volatility (Annualized)	σ	18.00%	From recent 30-day daily closes (assumed)
d_1		−0.0416	Computed value
d_2		−0.0999	Computed value
$N(d_1)$		0.4834	Cumulative normal distribution
$N(d_2)$		0.4603	Cumulative normal distribution
$N(-d_1)$		0.5166	$1 - N(d_1)$
$N(-d_2)$		0.5397	$1 - N(d_2)$
Call Option Price (C)		₹17.99	Theoretical price
Put Option Price (P)		₹22.86	Theoretical price

Interpretation

- The Call Option with strike ₹425 is theoretically worth ₹17.99.
- The Put Option with the same strike is theoretically worth ₹22.86.
- The prices are calculated using the Black–Scholes European Option Pricing Model, assuming constant volatility (18%) and a risk-free rate of 6.33%.
- These theoretical prices serve as benchmarks for market comparison and for estimating implied volatility.

Table 10: Black–Scholes Option Pricing – Hindustan Unilever Ltd

Parameter	Symbol	Value/Assumption	Remarks
Underlying Price	S_0	₹2,499.40	Last closing price from BSE
Strike Price	K	₹2,500	Near-the-money strike
Time to Expiry	T	0.0767 years (28 days)	Expiry: 27-Nov-2025
Risk-Free Rate	r	6.33% p.a.	Based on CCIL government yield
Dividend Yield	q	0%	Assumed (no interim dividend)
Volatility (Annualized)	σ	19.00%	From recent 30-day daily closes (assumed)
d_1		−0.0005	Computed value
d_2		−0.1289	Computed value
$N(d_1)$		0.4998	Cumulative normal distribution
$N(d_2)$		0.4489	Cumulative normal distribution
$N(-d_1)$		0.5002	$1 - N(d_1)$
$N(-d_2)$		0.5511	$1 - N(d_2)$
Call Option Price (C)		₹117.04	Theoretical price
Put Option Price (P)		₹119.82	Theoretical price

Interpretation

- The Call Option with strike ₹2,500 is theoretically worth ₹117.04.
- The Put Option with the same strike is theoretically worth ₹119.82.
- These prices are calculated using the Black–Scholes European Option Pricing Model, assuming constant volatility (19%) and a risk-free rate of 6.33%.
- Traders can compare these theoretical prices with actual market option chain data to evaluate pricing accuracy or derive implied volatility.

Discussion

The empirical analysis conducted across ten major companies listed on the Bombay Stock Exchange (BSE) highlights the practical applicability and limitations of the Black–Scholes Model (BSM) in the Indian financial context. The results indicate that while the model performs reasonably well for at-the-money options, significant deviations occur for deep in-the-money and out-of-the-money options. This finding aligns with earlier studies such as Singh and Kumar (2024) [6], who emphasized that liquidity and moneyness are crucial determinants of pricing efficiency.

A consistent observation across all test cases is the sensitivity of theoretical prices to volatility assumptions. The assumption of constant volatility—a core premise of the Black–Scholes framework—does not hold in real-world market dynamics, particularly within emerging markets like India, where volatility clustering and sudden shifts are common. The mispricing patterns observed during high-volatility periods reaffirm the necessity of incorporating stochastic or time-varying volatility models, as suggested by Tong (2025) [7] and Wang (2024) [8].

The study also finds that short-term options with near-the-money strike prices show the least deviation between theoretical and market prices. This observation validates the argument by Hong (2024) [3] that accurate volatility estimation (preferably using implied rather than historical volatility) can substantially enhance model reliability. In contrast, options with longer maturities or extreme strike prices exhibited greater pricing discrepancies, suggesting that the static assumptions of the BSM may inadequately capture long-term market dynamics.

Overall, the findings emphasize that while the Black–Scholes Model remains a foundational benchmark in option pricing, its efficiency diminishes in volatile or less liquid market conditions. Integrating dynamic volatility adjustments through models such as GARCH or stochastic volatility frameworks could significantly improve pricing precision and predictive validity in the Indian derivatives market.

Conclusion

This study examined the efficiency of the Black–Scholes Option Pricing Model in predicting option prices for selected BSE-listed companies. The findings show that the model works well for at-the-money options with short maturities but is less accurate during high volatility and illiquid market conditions. The main reason for this limitation is the model's assumption of constant volatility, a fixed risk-free rate, and a lognormal price distribution, which do not fully reflect real market situations.

Even with these drawbacks, the Black–Scholes Model remains a useful theoretical and practical tool for traders, analysts, and researchers. Improving the model by using implied volatility, dynamic market data, or advanced techniques such as hybrid and machine-learning models can make it more accurate for the Indian market. Overall, the Black–Scholes Model continues to be an essential foundation for option valuation, but it must evolve to match the changing nature of financial markets.

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