FinSearch End-Term Report

Accuracy of the Black–Scholes Model on Nifty50 Options

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14 August 2025

1 Introduction

The Black–Scholes Model (BSM) is one of the most widely used frameworks for pricing European-style options. While the model provides elegant closed-form solutions, its accuracy depends heavily on the realism of its assumptions and the quality of input data. In this report, we assess the accuracy of the BSM in pricing Nifty50 index options by comparing its calculated prices with actual market prices obtained from the NSE option chain.

We also provide a brief overview of Monte Carlo simulations as an alternative numerical method for option pricing.

2 Black–Scholes Model Overview

2.1 Mathematical Formulation

The BSM assumes that the underlying asset price S_t follows a geometric Brownian motion:

$$dS_t = \mu S_t \, dt + \sigma S_t \, dW_t$$

where μ is the drift, σ is volatility, and W_t is a standard Wiener process.

For a European call:

$$C = S_0 N(d_1) - Ke^{-rT} N(d_2)$$

For a European put:

$$P = Ke^{-rT} N(-d_2) - S_0 N(-d_1)$$

with:

$$d_1 = \frac{\ln(S_0/K) + (r + \frac{1}{2}\sigma^2)T}{\sigma\sqrt{T}}, \quad d_2 = d_1 - \sigma\sqrt{T}$$

2.2 Key Assumptions

- Log-normal asset returns
- Constant volatility and risk-free rate

- No dividends (or constant dividend yield in BSM–Merton extension)
- No transaction costs or taxes
- European exercise only

3 Implementation on Nifty50 Options

3.1 Data Source

We used the NSE option chain data for Nifty50 with a fixed expiry date (28-Aug-2025). The dataset included strike prices, option type, last traded price, and implied volatility (IV). The spot price was taken as the Nifty50 closing price from Yahoo Finance.

3.2 Python Implementation

The Black–Scholes pricing function was implemented as:

$$\texttt{d1} = \frac{\ln(S/K) + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}}$$
$$\texttt{d2} = \texttt{d1} - \sigma\sqrt{T}$$

with call and put prices computed using the cumulative normal distribution $\Phi(\cdot)$.

Time to expiry T was calculated as:

$$T = \frac{\text{Days to Expiry}}{252}$$

to match trading-day annualization conventions.

3.3 Results

For the dataset with expiry 28-Aug-2025:

- Spot Price: Rs. 24631.30
- Mean Absolute Error (MAE): 28.0337
- Root Mean Squared Error (RMSE): 43.6937

Table 1: Sample Output Comparison

Strike	Type	Market Price	BS Price	IV
22600	Call	1958.90	2095.33	0.0000
22600	Put	4.60	12.46	0.2068
22700	Call	1861.15	1995.62	0.0000
22700	Put	5.75	14.21	0.2035

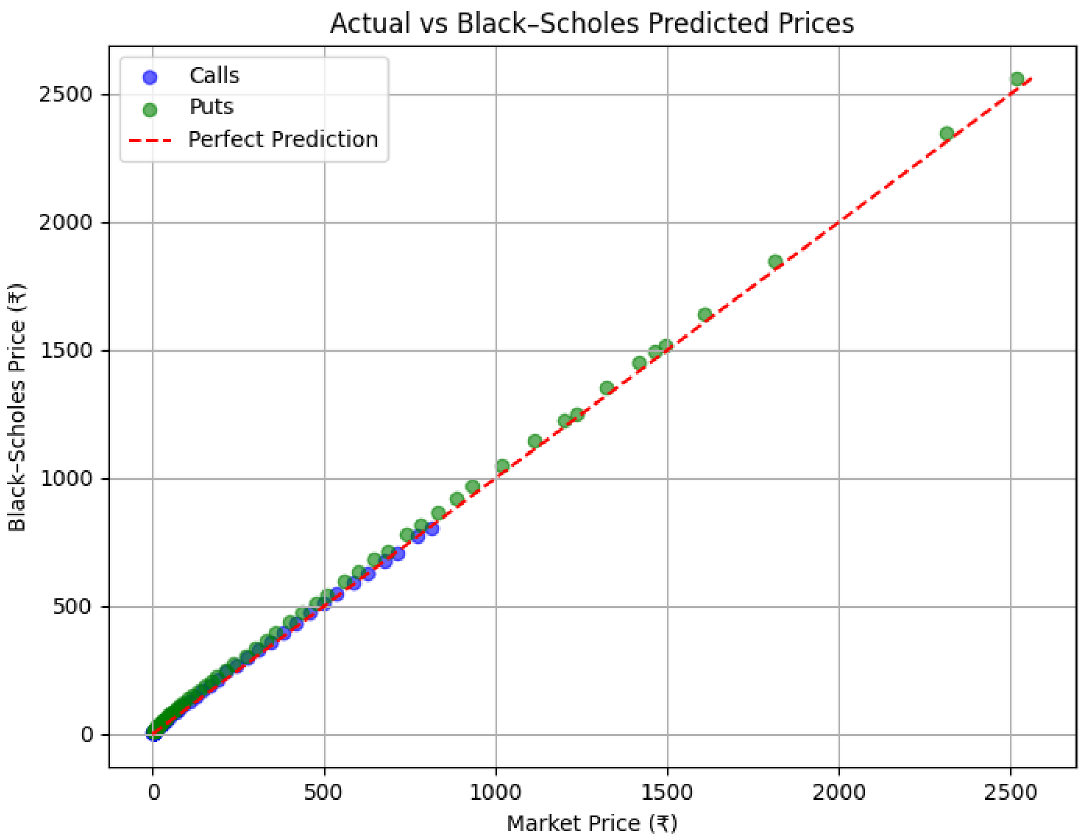

Figure 1: Actual vs Predicted Prices

4 Plots

5 Possible Sources of Error

Several factors can explain the observed discrepancies:

1. **Missing IV for ITM Options:** NSE often reports IV only for OTM contracts, leaving ITM IV as zero.
2. **Spot Price Mismatch:** Market prices in the option chain snapshot may differ from Yahoo Finance spot prices.
3. **Dividends:** Nifty50 constituents pay dividends, which are ignored in the vanilla BSM.
4. **Market Microstructure Effects:** Bid–ask spreads, illiquidity, and stale quotes can cause deviations.

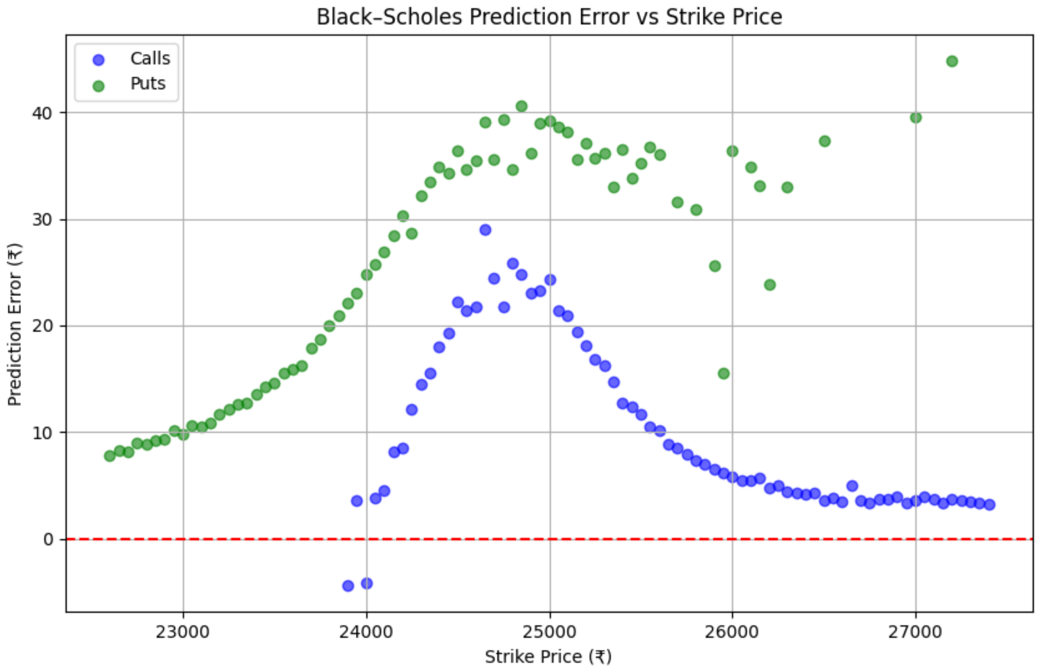

Figure 2: Prediction Error vs Strike price

6 Monte Carlo Simulations: A Brief Overview

Monte Carlo simulation is a flexible numerical technique for option pricing, especially useful for complex payoffs and path-dependent derivatives.

6.1 Method

1. Simulate many possible paths for the underlying asset using:

$$S_{t+\Delta t} = S_t \exp\left[\left(r - \frac{\sigma^2}{2}\right)\Delta t + \sigma\sqrt{\Delta t}Z\right], \quad Z \sim N(0,1)$$

2. Compute the payoff for each path at maturity.

3. Discount the average payoff at the risk-free rate.

6.2 Advantages

- Handles exotic and path-dependent options
- Flexible with respect to underlying dynamics
- Parallelizable for large simulations

6.3 Limitations

- Computationally expensive
- Convergence rate is slow ($\mathcal{O}(1/\sqrt{N})$)

7 Conclusion

The Black–Scholes model, when applied to Nifty50 index options, shows reasonable accuracy but with notable pricing errors, particularly for deep ITM/OTM options. These discrepancies are largely attributable to data limitations (missing IVs), spot price mismatches, and the omission of dividend yields.

Monte Carlo simulations offer a robust alternative for more complex instruments, albeit at a higher computational cost.