Name: Mahak Manzoor
Supervisor: Prof. Saif Siddiqui
Co-Supervisor: Dr. Khalid K. Qurashi
Department: Department of Management Studies

Notification Date: 08-05-2025
Notification Number: 578/2025

Topic: Implied Volatility Estimation and Option Pricing: A Case of Indian Capital Market

Keywords: Option pricing, Black and Scholes Model, Implied Volatility Estimation, Newton Raphson, VIX, Error Metrics

Findings

This study investigates the dynamics across the equity options market during different periods and expiration months. In Period 1, Call Near Options had the highest returns and lowest volatility. For Puts, Put Far Options had the highest mean, while Put Near Options showed least volatility. Among all series, Nifty 50 had the least volatility. A negatively skewed pattern indicated a higher chance of negative returns. Jarque-Bera results confirmed non-normality in all series. In Period 2, Call Near and Put Near Options had highest returns, and Put Next Options showed minimum volatility. Nifty 50 again had lower volatility and returns compared to the derivative market. Non-normality persisted across all series.

The ADF test in Period 1 found most series, including Nifty 50, Call Near/Far, and Put Near/Far, to be non-stationary, but made stationary through first differencing. Call Next and Put Next were already stationary. In Period 2, only Call Next Options were stationary, while others, including the underlying asset, were non-stationary, indicating mixed stationarity.

The Johansen Cointegration Test revealed a long-term relationship between the spot and derivatives markets in both periods, especially for Far options (Call and Put), with both trace and maximum eigenvalue statistics supporting the result.

The ARCH-LM test showed presence of volatility in all series in both periods except Put Far Options in Period 2. In Period 1, Nifty 50's returns were rising, and GARCH effects were evident. Call Far and Put Far options displayed volatility persistence ($\alpha + \beta$ close to 1). In Period 2, Put Far Options showed no fluctuations in ARCH test. However, the EGARCH results indicated asymmetry in shock impacts. Nifty 50 responded more to positive news in both periods. Call Far Options were symmetrical in Period 1 but asymmetrical during COVID-19, with bad news affecting pricing more. Put Far Options remained symmetrical across both periods.

Using the Black-Scholes model, option prices were forecasted and compared with actual prices. For Call Near Options, a MAE of 43.39 against an average price of 80.05 suggested poor fit, while Next and Far-month options performed better. MAPE exceeded 50%, implying low robustness. Still, Call Far Options showed least errors, supported by RMSE findings. For Put Options, BS model was more accurate for Next and Far-month expiries, while Near Options showed higher errors. MAPE and RMSE echoed the Call results, again suggesting better accuracy for longer-maturity contracts, regardless of type.

Implied Volatility (IV) was calculated using Newton-Raphson and compared with VIX during COVID-19. Average IVs were 13.19% (Call) and 22.8% (Put). A mean-reverting pattern was observed. High IV values suggested potential for larger price movements, increasing premiums—favourable for selling. Lower IVs encouraged buying. NR vs. VIX comparison for Far Options: MAE was 7.38 (Call) and 3.88 (Put); MAPE was 0.37 (Call) and 0.18 (Put); RMSE was 9.65 (Call) and 6.41 (Put). Results show NR predicted IV better for Puts, with values close to VIX. Accuracy could further improve by using implied volatility in BS model instead of historical.

The Greeks showed how sensitive options were to input parameters. For Far-month Call Options the Delta was positive (0–1), confirming direct relation with spot price. Gamma was positive and >1, with a bell curve. Vega ranged from 0–34.6%, average 17.3%. Theta was negative (–0.4 to –7.6). Furthermore, Rho was positive, indicating rising interest rates increased option prices (0.6–30.4), though less influential. For Put Options the Delta was negative and Gamma was again positive (>1). Theta was both positive or negative. Vega remained positive and Rho was negative, meaning higher interest rates led to lower put prices.