Project Report: Parametric Implied Volatility using NIFTY Options

Project Overview:

- The goal of this project is to compute and analyze the implied volatility (IV) surface of NIFTY options.
- This study involves fetching live option chain data, computing implied volatility using numerical methods, and visualizing its variation across strikes and expiries in the form of a volatility surface.

Tools Used

1. Python 2. Pandas 3. NumPy 4. SciPy (brentq root-finding method) 5. Matplotlib & Plotly 6. NSE Option Chain Data: Black-Scholes Model:

Data Collection and Preprocessing

- Source: The NIFTY option chain was fetched directly from the NSE website.
- Relevant fields like 'Strike, Spot_price (current NIFTY index level), Close_price (option price), and Expiry (option expiry date)' extracted:
- The data was cleaned and structured into a DataFrame.

Computing Implied Volatility

- For each option entry, implied volatility was computed using the Black-Scholes model. Since Black-Scholes does not offer an analytical formula to solve for volatility, it was numerically inverted using the brentq method from scipy.optimize.
- The assumptions for the Black-Scholes model included:
  - European-style options
  - Constant risk-free rate (r = 0.65)
  - No dividends
- A new column IV was appended to the DataFrame to store the computed implied volatilities.

Visualization and Analysis

- Term Structure
  - Time Series of IV for Fixed Strike
  - Selected strikes within ±1% of the closest strike to the spot price to ensure relevance and liquidity.
  - For a fixed strike, the variation of implied volatility over time to maturity was plotted.
  - This helps analyze how near-the-money option IVs evolve as expiry approaches.
- Smile Patterns
  - The DataFrame was grouped by expiry, and for each group, a plot of log-moneyness (ln(K/S)) versus IV was created.
  - These plots display the volatility smile or skew, a well-known feature in real-world markets deviating from the flat IV curve assumed by Black-Scholes.
- Volatility Surface Construction
  - Using cubic interpolation, a smooth surface of implied volatility as a function of strike and time to maturity was created.
  - This 3D volatility surface helps visualize market sentiment comprehensively across different strikes and maturities.

Outcomes and Insights

- The project successfully constructed a parametric volatility surface from real market data.
- Observed volatility smiles and term structure patterns consistent with empirical market behavior.

Future Work and Extensions

- Introduce stochastic volatility models (like Heston) to better capture observed IV dynamics.
- Add real-time updating capability with automated fetching and plotting.
- Integrate put options for a more holistic view.
- Explore regression or machine learning techniques to parametrize the volatility surface more robustly.

Conclusion

- This project bridges quantitative finance theory with practical market data analysis. By extracting and visualizing the implied volatility surface from NIFTY options, it enhances our understanding of market expectations and risk, and sets the stage for more advanced modeling and strategy development.