Derivatives: Pricing, Greeks, and Hedging (Day 42–47)

Module Focus: Bridging Theory and Market Practice

- Goal: Establish options as key tools for risk management, income generation, and portfolio design.
- Methodology: Implement and compare BSM and Binomial models, applying Greeks for live analysis.
- Outcome: Transform investors into risk architects through systematic risk–reward design.

Derivatives Foundations & The Importance of Greeks

Topic: Options – The Third Dimension of Investing

- Options add a third dimension: managing risk through time, volatility, and probability.
- Leverage & Flexibility: Control large notional value with less capital; enable spreads/collars.
- Risk Management: Options as insurance (Protective Puts) or yield enhancers (Covered Calls).
- Greeks measure sensitivity to market variables — foundation for risk control.
- Key Greeks: Δ, Γ, Θ, ν, ρ — manage directional, convexity, time, volatility, and rate risks.

BSM Model & Market Mispricing Scanner

Topic: Black-Scholes Pricing and Arbitrage Signal Generation

- BSM: Closed-form benchmark for European option pricing and Greeks.
- Limitations: Constant volatility/rates, ignores frictions.
- NSE Scanner: Python tool fetching live data (NIFTY, M&M) and computing model vs. market.
- Signals: BUY (undervalued) / SELL (overvalued) based on 3% deviation threshold.
- Findings: NIFTY puts undervalued (-84%), calls slightly overvalued (+16.7%); illiquidity likely.

BSM vs. Binomial Tree (CRR) Comparison

Topic: Analytical Speed Meets Numerical Flexibility

- BSM: Continuous-time analytical model for European options.
- Binomial (CRR): Discrete-time numerical model handling American options.
- Binomial converges to BSM as step count increases.
- Insight: Undervalued PUTs & overpriced CALLs indicate downside and rising volatility.
- Modern Models: Extend with stochastic volatility and jump-diffusion frameworks.

In-Depth Analytical Greeks Analysis

Topic: Decomposing Risk: Understanding Sensitivity Measures

- Objective: Compute and visualize five Greeks across strike prices.
- Δ (Delta): Directional risk measure; basis for delta-neutral hedging.
- Γ (Gamma): Convexity; peaks near ATM – guides hedge adjustment frequency.
- v (Vega): Volatility sensitivity; high near ATM – enables volatility trading.
- Θ (Theta) & ρ (Rho): Capture time decay and interest rate risk.

Greeks in Practice – Delta Hedging Simulation

Topic: Neutralizing Directional Risk via Self-Financing Replication

- Simulated delta-hedging with Monte Carlo paths (risk-neutral drift).
- Daily stock adjustment maintains delta neutrality.
- Self-financing rule: No additional capital after setup.
- Results: PnL volatility reduced ~4–5× (4.69× Call, 4.02× Put).
- Mean hedged PnL ≈ 0 → effective directional risk neutralization.

Quantitative Results Summary & Residual Risk

Topic: Measuring Hedge Effectiveness and Remaining Exposures

- **NIFTY:** Puts undervalued (-30% to -84%), Calls slightly overvalued → volatility skew.
- **M&M:** OTM puts moderately undervalued (10–23%) → suitable for protective hedging.
- **Residual Risks:**
  - Discrete Rebalancing (Gamma PnL)
  - Vega Risk (constant volatility assumption)
  - Theta Decay (time erosion in long positions)

Key Takeaways & Strategic Insights

Topic: Translating Quant Analysis into Strategy

- BSM & Binomial remain foundational for pricing and calibration.
- Delta-hedging reduces portfolio volatility 4–5× → measurable risk control.
- Mispricing signals highlight tactical volatility trades (cheap PUTs = rising vol).
- Realism requires handling volatility smiles, fat tails, stochastic vol.
- Modern frameworks: Heston, SABR, Jump-Diffusion enhance robustness.

Conclusion & Future Directions

Topic: Next Steps in Adaptive Trading

- Achievements: Implemented pricing models, applied Greeks, simulated hedging.
- Outcome: Translated theory into quantifiable risk metrics.
- Adaptive Goal: Merge classical rigor with data-driven calibration.
- **Next Steps:**
    - Integrate real-time volatility surfaces.
    - Apply hybrid models (e.g., Heston + Binomial).
    - Compute American Greeks from Binomial trees.
    - Explore ML-driven adaptive hedging frameworks.