Executive Summary PDF
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This project implements a full workflow for equity option analysis under a Merton Jump Diffusion framework using daily market data pulled from `yfinance`. After building a clean multi asset price panel: AAPL, TSLA, NVDA, and GOOG to name a few, we computed log returns and basic distributional statistics to confirm the presence of fat tails and volatility differences across names. We then calibrated a Merton Jump Diffusion model to each ticker via maximum likelihood, estimating diffusion volatility, jump intensity, and jump size parameters, with caps and penalties to avoid unrealistically high jump frequencies. Using these fitted parameters, we simulated Jump Diffusion price paths and priced American put options, and we compared those values to a Black–Scholes binomial benchmark. Finally, we evaluated delta–hedging performance in a "true" jump world while the hedge relied on Black–Scholes deltas, and we summarized how greater jump volatility was associated with larger hedging P&L dispersion. Overall, the results illustrate that jumps matter both for American option valuation and for the stability of hedging strategies, especially in high-jump names such as AAPL and TSLA, which we performed Delta Hedging on.

Merton Jump Diffusion Model Equation:

$$dS_t = S_t \left((\mu - \lambda\kappa)\, dt + \sigma\, dW_t + dJ_t \right)$$

where

$$\kappa = \mathbb{E}\left[e^{Y} - 1\right]$$

and $Y \sim \mathcal{N}(\mu_J, \sigma_J^2)$ represents the logarithmic jump size, λ is the average jump intensity at the Poisson arrival rate, σ is the diffusion volatility, and dW_t is a standard Wiener process. The term dJ_t captures the random jumps in price, modeled as a compound Poisson process:

$$dJ_t = \sum_{i=1}^{N_t} (e^{Y_i} - 1)$$

where $N_t \sim \text{Poisson}(\lambda t)$