

Option trading simulation under Heston's Model

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1 Executive Summary

A solid understanding of stock price dynamics can greatly help mitigate unnecessary risk in modern trading. In this project, we employ mathematical and data analytic tools to study the stock movements of Netflix, simulate the trading of a Netflix option, and develop profit-protection strategies for option trading.

We begin by extracting real-world stock data from the Yahoo Finance database to calibrate a financial model that simulates the stock price movement of *Netflix*. After calibration, in the spirit of Monte Carlo, we repeatedly simulate the final profits of trading a European call option with Netflix as the underlying asset. Based on the option, we then develop three hedging portfolios, each designed to reduce exposure to specific sources of randomness in stock movements. Simulation results show that these portfolios effectively protect profits, as evidenced by the histogram distributions.

There are two main highlights of our project. First is the use of Heston's model to capture stock price dynamics. Compared to the classic Black-Scholes model, which assumes constant volatility, the Heston model captures stochastic volatility more realistically, enhancing the precision and robustness of the simulations. The second highlight is our "mixed" hedging strategy, which addresses multiple sources of risk simultaneously. Specifically, we construct a Delta-Vega hedging portfolio that achieves both Delta neutrality (insensitivity to changes in the spot price) and Vega neutrality (insensitivity to volatility changes). For comparison, we also implement Delta-only and Vega-only hedging strategies. From the simulation histograms and statistical analysis, the Delta-Vega strategy clearly demonstrates superior profit protection, although all three hedging approaches outperform the unhedged portfolio.

Throughout the project, we utilize powerful data analysis and visualization tools from Python libraries such as NumPy, Pandas, SciPy, Matplotlib, and Seaborn. We also apply methods from data analysis and computational finance, including Monte Carlo simulations (for profit modeling), least-squares regression (for model calibration), and numerical integration (for option pricing and Greeks calculation). Additionally, theoretical concepts from stochastic calculus (Greek formulae) and mathematical statistics (result analysis) are consistently put into practice.

Finally, we propose two directions for future work. First, we may explore more advanced stock models, such as GARCH models. Second, we may extend the framework to simulate derivatives trading and hedging under more sophisticated rules, including American or Bermudan options.