Mini Project Showcase
Quant Finance Boot Camp Summer 2025

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Project 1: Construction of High & Low-Risk Portfolios (I)

Objective:

- Construct two potentially profitable portfolios using current stock data
- One high-risk (growth-focused), one low-risk (defensive)

Data Collection:

- 2 years of daily closing prices for 10 large-cap stocks (AAPL, MSFT, TSLA, etc.)
- P/E ratios collected via Yahoo Finance API

Methodology:

- Computed annualized return, volatility, covariance matrix, beta, P/E
- Portfolio weights optimized using SLSQP to maximize Sharpe Ratio

Project 1: Construction of High & Low-Risk Portfolios (II)

Portfolio Constraints:

High-risk:

- Minimum expected return 12%
- Minimum volatility 20%
- At least 30% allocated to high-beta stocks (TSLA, NVDA, GOOGL)
- Weighted portfolio P/E ratio minimum 25
- Minimum 5% allocation per stock

Low-risk:

- Maximum volatility 15%
- At least 40% in KO, JNJ, PG, PEP
- Weighted portfolio P/E ratio max 20
- Combined TSLA and NVDA max 10%
- Minimum 5% allocation per stock

Results:

- High-risk (with min weight): 29.5% return, 20% volatility
- Low-risk(with min weight): 6.6% return, 13.3% volatility
- High-risk (without min weight): 34% return, 20% volatility
- Low-risk (without min weight): 18.5% return, 15% volatility

Project 2: Hypothesis Testing of Standard Assumptions (I)

Objective:

- Test whether individual stocks or portfolios have normally distributed log returns
- Explore how outlier trimming and rolling windows affect normality

Data Collection:

- 5 years of daily adjusted close prices for 10 large-cap stocks (e.g., AAPL, TSLA, KO).
- Log returns computed as $r_t = \log\left(\frac{P_t}{P_{t-1}}\right)$

Methodology:

- Applied three normality tests: Shapiro–Wilk, Jarque–Bera, Anderson–Darling
- Used 126-day rolling windows to assess local normality
- Trimmed top/bottom $= 3\%$ returns to reduce tail effects

Project 2: Hypothesis Testing of Standard Assumptions (II)

Key Results:

- **XOM** passed normality in 80% of rolling windows
- After 3% trimming, 5 stocks (e.g., KO, NVDA) passed AD test
- Constructed trimmed 5-stock portfolio passed all 3 tests
- High-risk portfolio from Project 1: 81% normal in rolling windows
- Low-risk portfolio: 70% normal

Conclusion:

- Log returns are rarely globally normal but often locally normal
- Trimming outliers improves normality across multiple stocks
- Statistical testing and visual tools (histograms, Q-Q plots) are both valuable

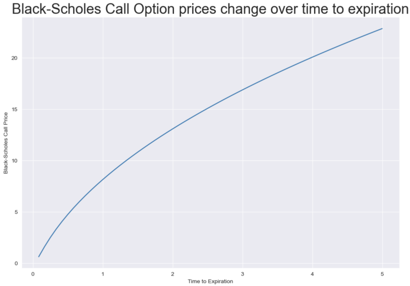
Project 3: Call Option Price Sensitivity

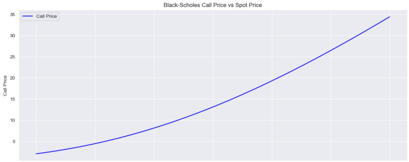
Call Option – Time Sensitivity:

- As time to expiration decreases, call price declines
- Rate of decay is nonlinear — faster near expiry (Theta more negative)
- Vega also shrinks as time shortens (volatility less impactful)

Call Option – Spot Price Sensitivity:

- Call price increases with spot price, forming a convex curve
- Delta increases from 0 to 1 as spot rises — the option becomes deep in-the-money
- Gamma peaks near ATM, then decreases as option becomes ITM/OTM





Project 3: Put Option Price Sensitivity

Put Option – Time Sensitivity:

- Put prices also decline with time, but with slightly different shape than calls
- Theta for puts is negative but smaller in magnitude away from ATM

Put Option – Spot Price Sensitivity:

- Put price increases as spot price falls
- Delta ranges from -1 to 0; steepest near ATM

Project 4:Delta Hedging under Non-constant Volatility (I)

Objective:

- Simulate profit distribution of a short call position under non-constant volatility
- Compare model-based profit distributions using three volatility processes
- Explore impact of non-constant volatility on profit distribution

Volatility Models Simulated:

- **Non-constant volatility:** sampled from a discrete distribution
- **Heston Model:** Mean-reverting variance with correlation (ρ) to price process
- **GARCH(1,1):** Time-varying volatility from past squared returns and volatility

Methodology:

- Simulated 2500 stock paths for each model
- Hedged daily (252) using Black–Scholes delta.
- Profit distribution for different drift(μ)

Project 4: Delta Hedging under Non-constant Volatility(II)

Results: Profit Distribution (1000 Contracts)

- Non-constant sigma (drift -0.4): Mean Profit$=-230$
- Non-constant sigma (drift 0.4): Mean Profit$=55$
- Heston (drift -0.4): Mean Profit $=765$
- Heston (drift 0.4): Mean Profit $=203$
- GARCH (drift -0.4): Mean Profit $=513$
- GARCH (drift 0.4): Mean Profit $=241$

Key Observations:

- **Drift Sensitivity:** Profits shift significantly with drift — bearish drift helps sellers
- **Model Risk:** Using BS premium under Heston or GARCH leads to optimistic profit
- **Tail Risk:** Hedging does not fully mitigate risk — max loss exceeded $15k in GARCH case

Summary

Mini Project Highlights:

- Constructed and optimized high-risk vs. low-risk investment portfolios
- Statistically tested log-return normality under real-world data and conditions
- Visualized option price sensitivity to Time and Spot price
- Simulated delta-hedged P&L under realistic stochastic volatility models

Thank You!