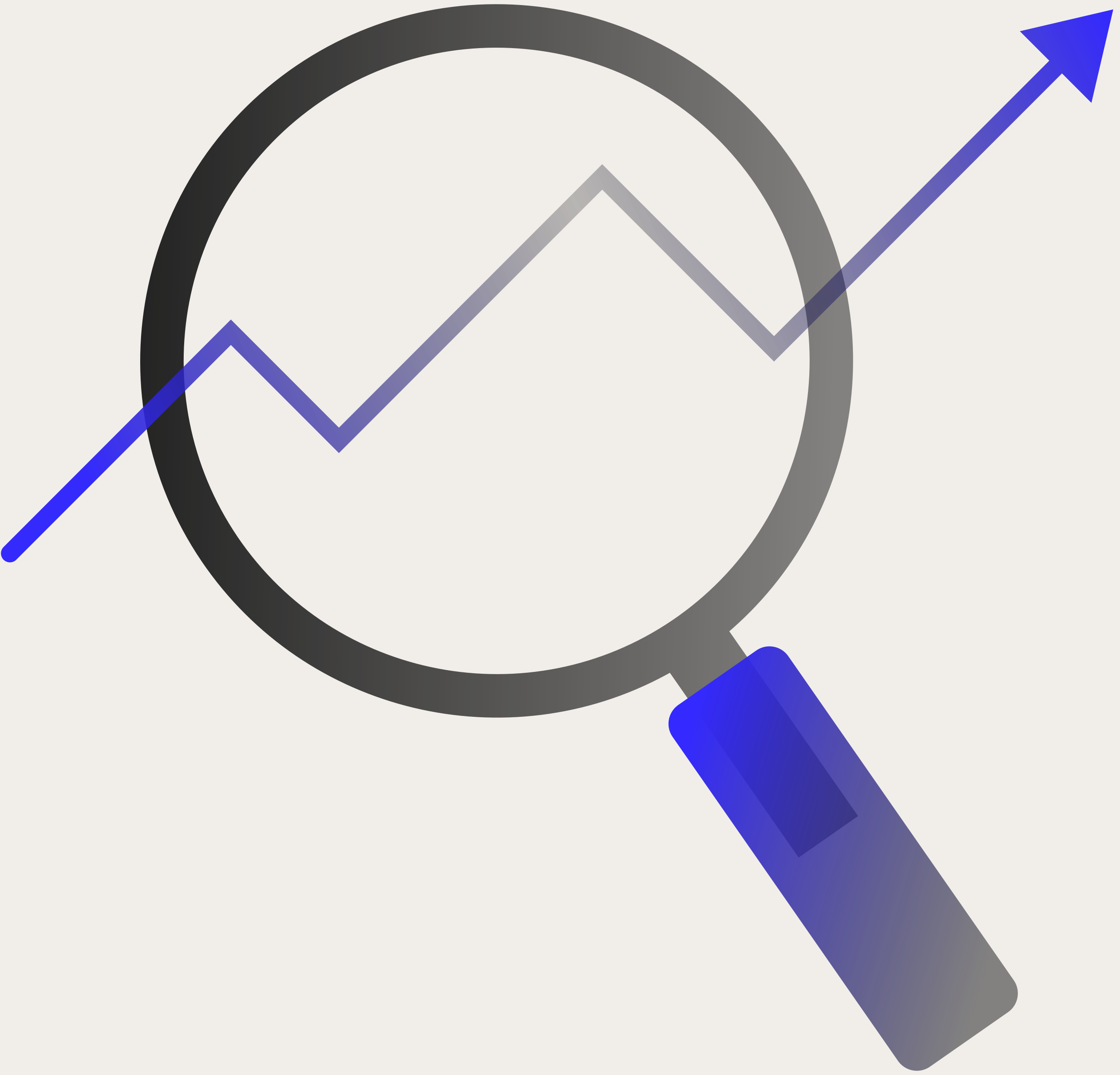
GSIH Finals (Quant)



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OPTIMAL HEDGING STRATEGY

Problem Statement

Identify a set of hedging stocks needed to **minimize risk**, while also considering the **cost** of implementing the hedge.

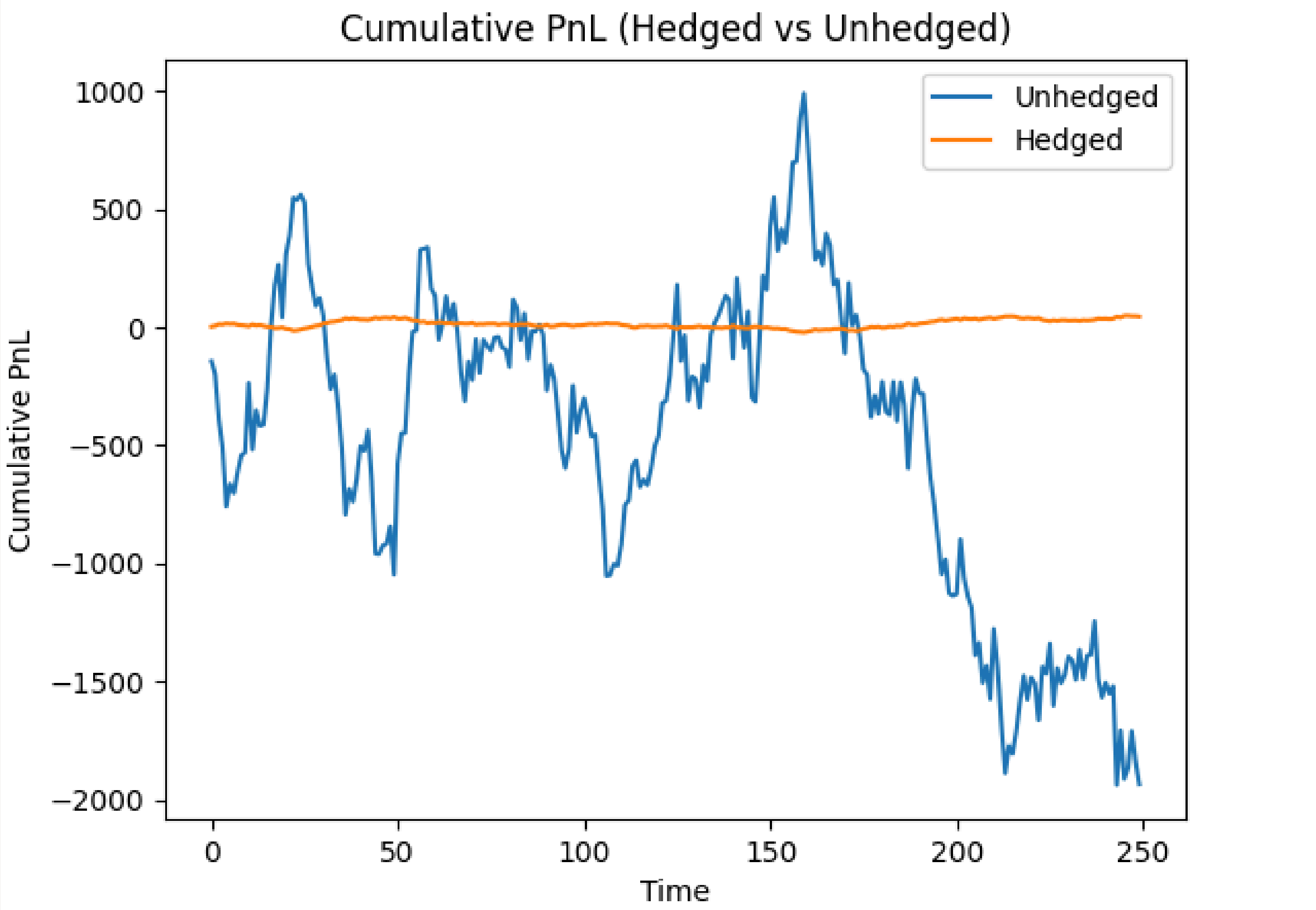
Models: L1 Regularization

Lasso Regression:

- Minimizes **MSE + L1 penalty**

Quantile Regression:

- Minimizes **quantile loss + L1 penalty**



Improvements & Alternatives

Feature Engineering

- Scaled returns using: Rating, Market_Cap, sector

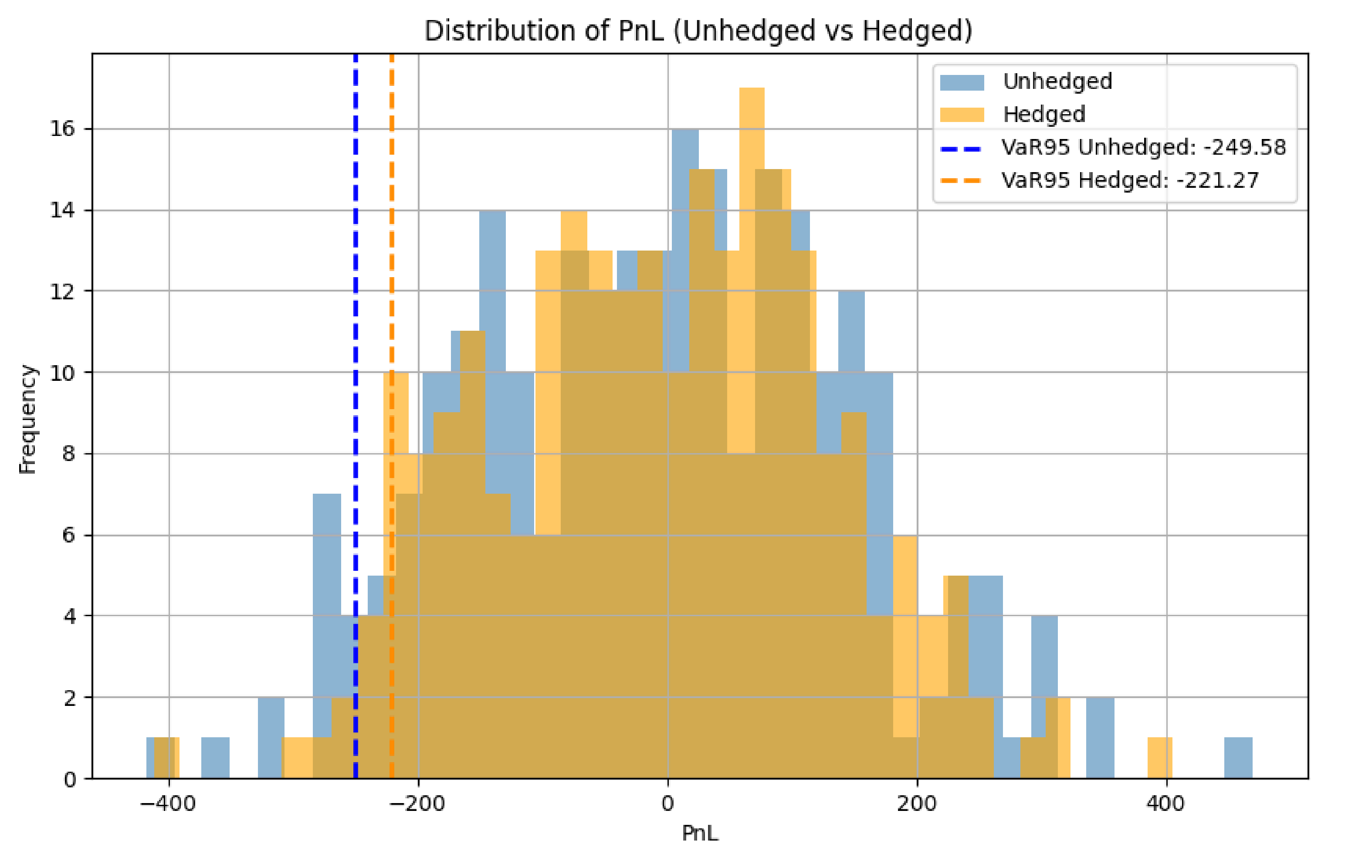
Non-Linear (Polynomial) Expansion

- **Issue:** Huge memory blowup (>91MB)
- **Not scalable** for 100s of stocks

LGBM / XGBoost for Non-Linear VaR Modeling

Rolling-Window Hedging

Minimize VaR(95) * cost



AUTOMATED MARKET MAKING

Problem Statement

Build an adaptive **quoting** strategy in a volatile environment that **maximizes total PnL** while keeping inventory within ±20 units.

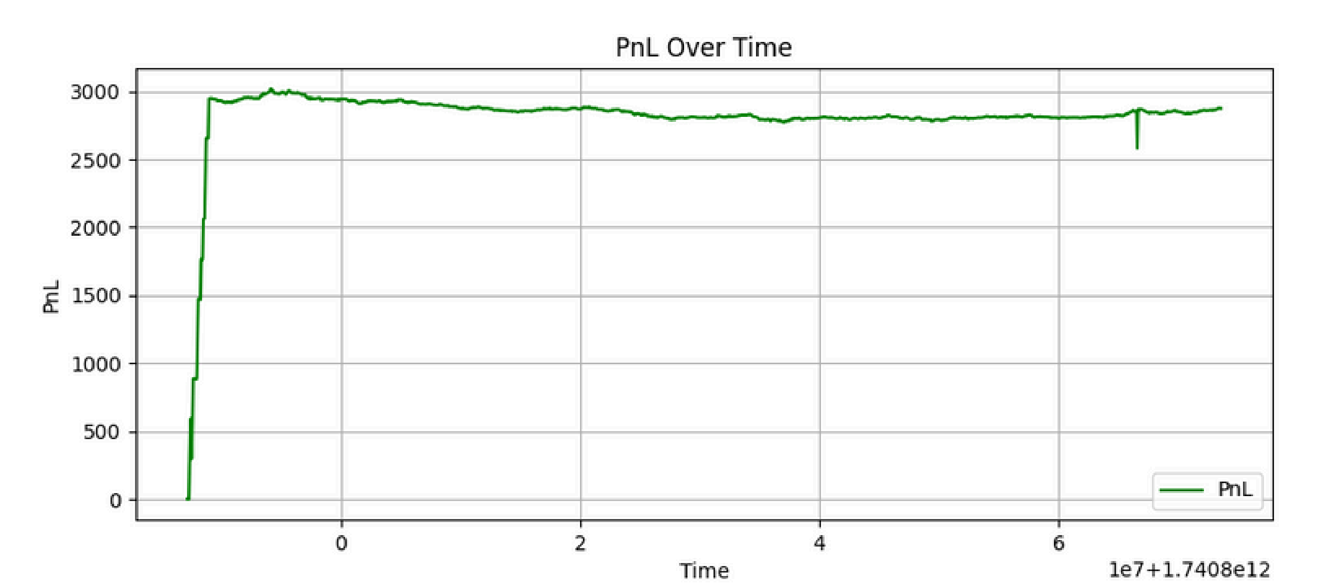
Avellaneda-Stoikov Model

- Generates Optimal bid-ask spread and deals with inventory risk.
- Added volatility smoothening and inventory management.

$$r_t = S_t - q_t \cdot \gamma \cdot \sigma^2 \cdot (T - t)$$

$$\delta_t = \gamma \cdot \sigma^2 \cdot (T - t) + \frac{2}{\gamma} \cdot \ln\left(1 + \frac{\gamma}{k}\right)$$

$$Bid = r_t - \frac{\delta_t}{2}, \quad Ask = r_t + \frac{\delta_t}{2}$$



Improvements & Alternatives

- Trade Pressure–Based Skew
- Order Flow Imbalance (OFI)
- Modified Bertsimas-Lo Model
- Cartea–Jaimungal Model
- Machine Learning Models

EXOTIC OPTION PRICING

Problem Statement

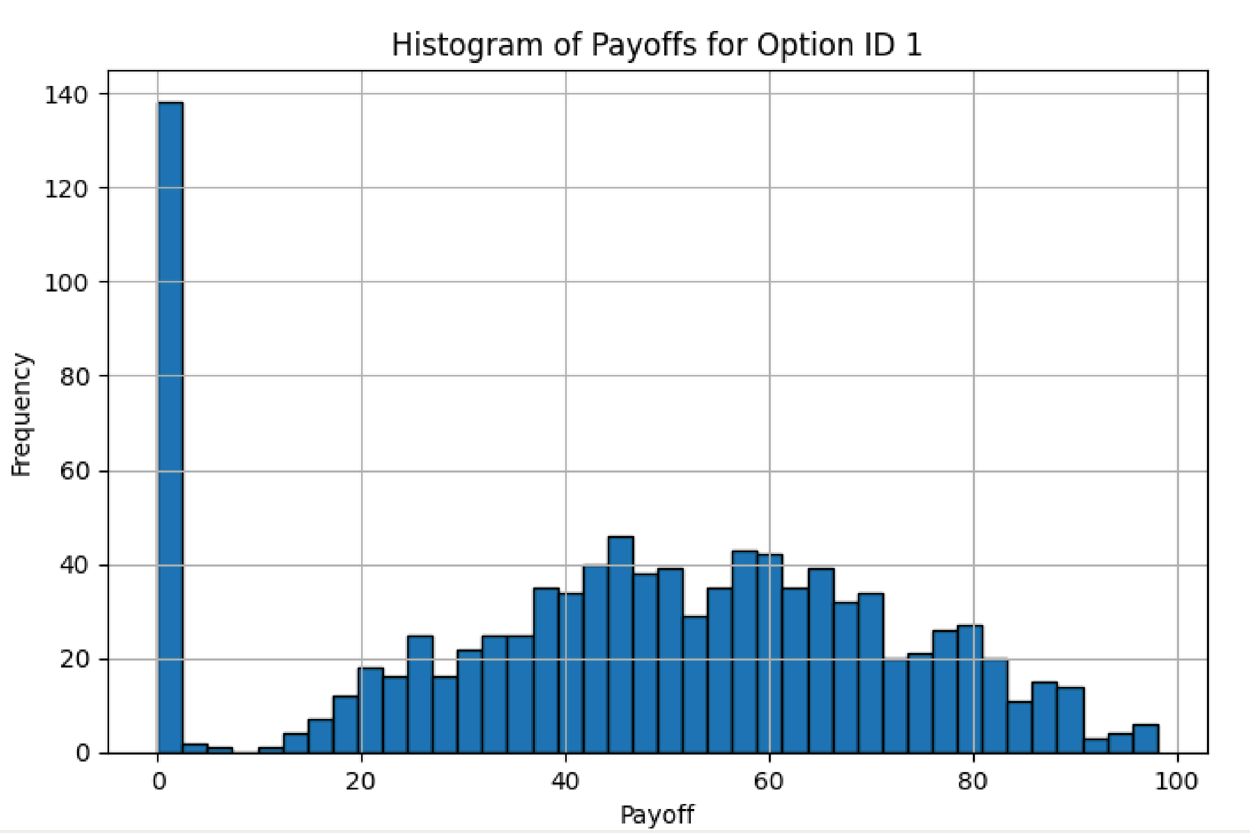
Price basket options of three correlated stocks using the local market volatility model:

dS(t)= r * S(t) * dt + σ(S(t), t) * S(t)* dW(t)

Approach

- Volatility Surface Calibration
- **Cholesky Decomposition** for BM Shocks
- **Monte Carlo Simulation** of GBM paths
- Basket Construction & Knock-out

$$S_{t+\Delta t} = S_t \cdot e^{(r - 0.5\,\sigma^2)\,\Delta t + \sigma\, dW_t}$$



Volatility Surface Calibration

Black Scholes Price Model

For each (K, T), solve for volatility such that Black-Scholes price matches the market price. Update the volatility using **Newton-Raphson** update rule.

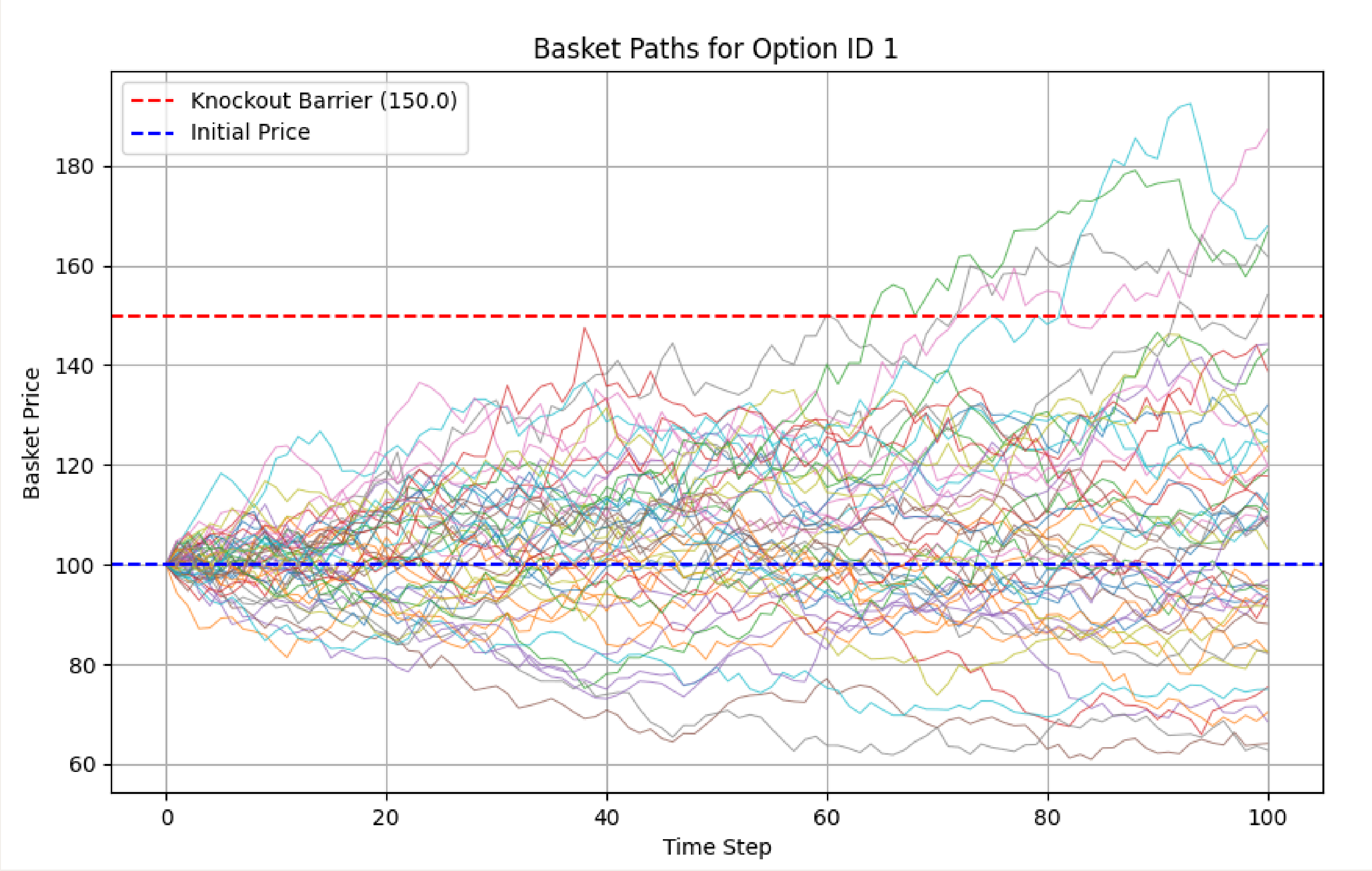
$$C = S_0 N(d_1) - K e^{-rT} N(d_2)$$

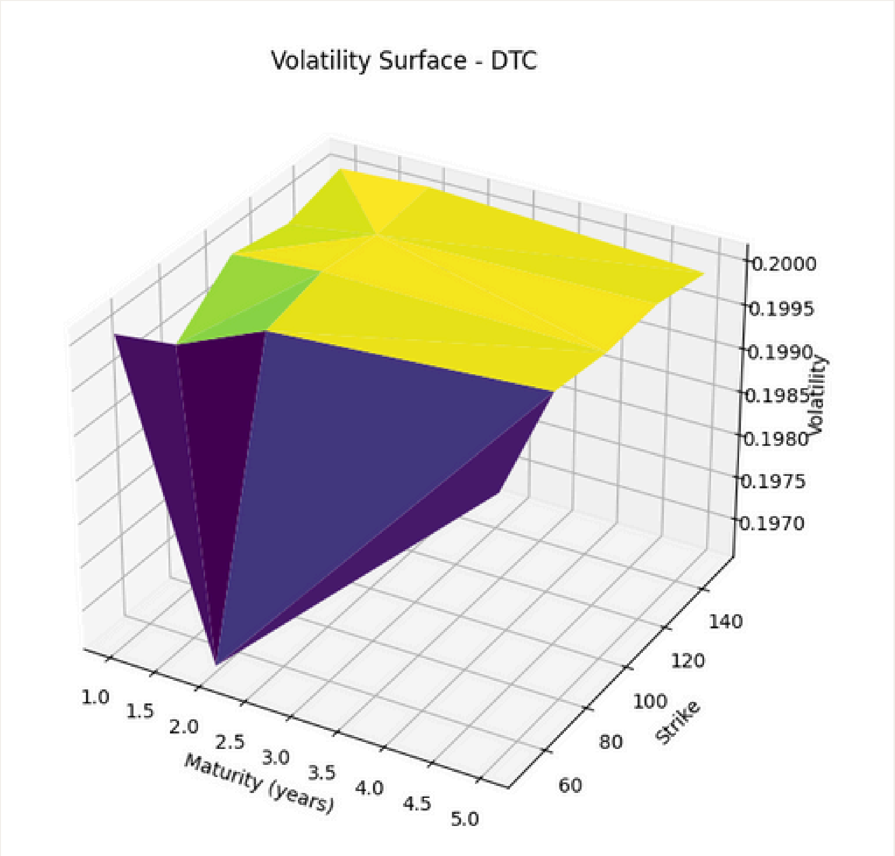
Alternative Methods

- **Monte-Carlo Estimation**
- **Dupire Local Volatility Model**
- **Heston Model**
- **Levenberg–Marquardt Method**

Challenges:

- **Computational Complexity**





Thank You