GOOGL Volatility Mean Reversion Options Strategy Report

1. Strategy Overview

This project explores an options trading strategy based on the mean-reversion tendencies of implied volatility, specifically focusing on the 30-day implied volatility (IV30) of GOOGL options. The idea behind the strategy is straightforward: when implied volatility rises significantly above historical norms, options become systematically overpriced relative to the stock's realized volatility. By recognizing this dislocation, we can construct trades that sell volatility at elevated levels, expecting volatility to revert and option premiums to decay in our favor.
GOOGL was chosen for this study due to its deep and liquid options market, regular volatility swings (especially around earnings), and extensive historical data availability. Our goal was to create a realistic, risk-managed approach that leverages volatility mispricings while accounting for common frictions like bid-ask spreads, commissions, and sudden volatility shocks.

2. Trading Logic

Entry Conditions:

- IV30 must exceed the 1-year rolling average by at least 0.9 standard deviations, signaling unusually high implied volatility relative to recent history
- IV30 must not be surging rapidly at the moment of entry; specifically, the change in IV30 over the previous 5 trading days must be less than +10%; this ensures we are not stepping into a runaway volatility event

Trade Structure:

- Sell one out-of-the-money (OTM) call option approximately 2.7% above the spot price
- Sell one out-of-the-money (OTM) put option approximately 4.0% below the spot price
- Hedge the position by delta-neutralizing using GOOGL stock, based on the combined deltas of the short options
- Adjust call implied volatility upward by 5% and put implied volatility upward by 10% to reflect observed real-world skew (puts generally trade at higher IVs than calls)
- Incorporate a 5% bid-ask spread penalty to simulate realistic fill prices

Risk Management:

- An IV30-based stop-loss: if IV30 spikes beyond +1.5 standard deviations from the 1-year mean after entry, the position is exited to limit exposure to adverse volatility moves
- A price-based stop-loss: if the stock price moves more than ±2% beyond the initial breakeven points, the position is exited
- Profit targets:

    - If 50% of the total premium is captured within the first 10 days, an early exit is triggered to lock in gains
    - A trailing stop is activated once 50% maximum profit is reached, to protect profits against reversals
    - If no exits are triggered, the position naturally expires after 30 calendar days

Special Feature:

- To introduce realism, we incorporated a 20% probability of a "shock event," simulating scenarios such as earnings surprises or macroeconomic shocks. In these cases, implied volatility is assumed to spike by 50% immediately after entry.

This structure balances aggressive premium capture with multiple layers of defense against both volatility and price risks.

3. Data Collection and Assumptions

Historical price and implied volatility data for GOOGL were collected primarily from Market Chameleon and supplemented by Yahoo Finance when necessary. Our dataset covers the period from early 2014 through mid-2025, allowing for robust long-term testing across multiple market regimes.

Key assumptions incorporated into the model include:

- A fixed 5% bid-ask spread adjustment to reflect real-world transaction costs
- A $0.50 commission per options contract traded
- A constant risk-free rate of 4% for Black-Scholes pricing
- Conservative option IV adjustments to account for skew and market behavior asymmetries.

These assumptions were intentionally chosen to reflect slightly conservative fills and costs, ensuring the strategy is not overly optimistic.

4. Strategic Rationale in Different Market Scenarios

Scenario A: Volatility Spike

- When GOOGL's IV surges following news events or market turbulence, options become disproportionately expensive relative to their true risk; by selling options under these conditions, the strategy exploits excessive fear priced into the market
- Built-in stop-loss triggers protect the portfolio from rare cases where volatility continues to rise unexpectedly after entry

Scenario B: Mean Reversion

- In typical market behavior, volatility spikes are followed by a gradual cooling off; as IV reverts toward its historical mean, option premiums decline, providing significant profits for the short strangle position

Scenario C: Slow, Stable Market

- In a low-volatility or sideways market, theta (time decay) naturally erodes the value of out-of-the-money options; the strategy benefits from premium collection even if the stock price remains relatively flat, as long as no sharp movements occur

The strategy is thus designed to be flexible, performing across a variety of volatility conditions, with multiple exit paths enhancing adaptability.

5. Methodology

1. **Theoretical Framework:** Under the risk-neutral measure Q, we model the underlying price S_t and its instantaneous variance v_t via the Heston stochastic volatility dynamics:

$$\frac{dS_t}{S_t} = r\,dt + \sqrt{v_t}\,dW_t^{(S)},$$
$$dv_t = \kappa(\theta - v_t)\,dt + \xi\sqrt{v_t}\,dW_t^{(v)},$$
$$\mathrm{Corr}\left(dW_t^{(S)}, dW_t^{(v)}\right) = \rho,$$

   Solving the Ornstein–Uhlenbeck component yields:

$$\mathbb{E}\left[v_t \mid v_s\right] = \theta + (v_s - \theta)\,e^{-\kappa(t-s)},$$

   and defines the variance half-life:

$$t_{1/2} = \frac{\ln 2}{\kappa},$$

   which underpins our entry threshold in units of historical variance dispersion.

2. **Data & Preprocessing**
   - Data Sources
     - Daily spot prices and 30-day implied volatility (IV30) for the chosen equity (2014–2025).
   - Cleaning & Imputation
     - Forward-fill any missing IV30 values.
     - If an entire window of IV30 is missing, substitute a conservative default of 20%.
   - Rolling Statistics
     - Compute a 252-trading-day rolling mean μ_{IV30} and standard deviation σ_{IV30} of IV30.

3. **Smile Construction & Signal Generation**
   - **Quadratic Smile Parameterization:**
     For each strike K at time t with current spot S_t define

$$\mathrm{IV}_t(K) = \mathrm{IV30}_t\left[1 + b\,(K/S_t - 1)^2\right],$$

     where b = 5

   - **Statistical Signal**

     Over a 252-day lookback, compute the mean μ_{smile} and variance σ_{smile} of IV(K).

Entry Condition: $IVt(K) > \mu_{smile} + 0.9\sigma_{smile}$

4. **Model Calibration**

Fixed Parameters

$$\kappa = 3.0, \quad \theta = \overline{v} \text{ (sample mean of } v), \quad \xi = 0.2, \quad \rho = -0.7.$$

Estimation of Θ

Θ is set to the historical average variance implied by IV30.

5. **Simulation Framework**

Euler Discretization:

Time step Δt (e.g.\ 1/252 year)

For each path and time increment, generate two correlated normals (z_1, z_2) with $corr(z_1, z_2) = \rho$

Update:

$$v_{t+\Delta t} = v_t + \kappa(\theta - v_t)\,\Delta t + \xi\sqrt{v_t}\,\sqrt{\Delta t}\,z_2,$$
$$S_{t+\Delta t} = S_t \exp\Big[\big(r - \tfrac{1}{2}v_t\big)\Delta t + \sqrt{v_t\,\Delta t}\,z_1\Big].$$

Enforce non-negativity $v_t \geq 0$.

Path Generation

Simulate N independent paths; record both S_t and v_t.

6. **Trade Implementation**
   - **Positioning:**
     Short strangle:
     Call at 2.7% OTM, put at 4.0% OTM.
     Delta hedging: use Black–Scholes deltas (adjusted for a 5% bid-ask spread).
   - **Transaction Costs**
     $0.50 per contract commission included in P&L.
   - **Exit Criteria**
     - Volatility reversion: IV falls below $\mu_{smile} + 0.9\sigma_{smile}$
     - Profit target or hard price stop.
     - Maximum holding period of 30 trading days.

7. **Backtest & Performance Metrics**
   - **Aggregate Metrics:** Total and annualized return, win rate and maximum drawdown

6. Strengths and Weaknesses

Strengths	Weaknesses
Clear, quantitative entry signals based on historical volatility statistics.	Exposure to tail risk events if large market moves occur faster than hedging or stops can react.
Delta-hedged entry to mitigate directional risk at initiation.	In extreme environments, volatility can remain elevated for longer periods than modeled.
Realistic treatment of frictions: bid-ask spreads, commissions, and event shocks.	Strategy effectiveness diminishes during extended periods of low volatility or minimal IV movement.
Multiple layered exit strategies (stop-losses, profit-taking, trailing stops).	Requires consistent liquidity to manage entry, delta hedging, and exit positions efficiently.

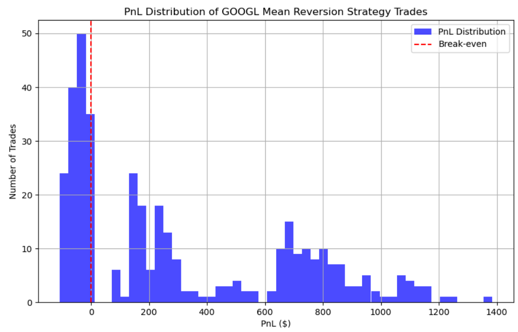
By explicitly accounting for market realities and embedding robust risk management, the strategy offers a practical framework that is suitable both for academic exploration and real-world implementation (with proper adjustments for margin requirements and hedging logistics).

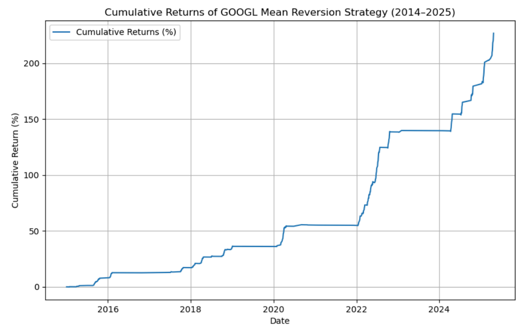
7. Backtest Results and Performance

The strategy was backtested across the full data period from 2014 to 2025, simulating realistic trading conditions:

Metric	Value
Initial Portfolio	$50,000
Final Portfolio	$163393.50
Total Return	226.79%
Annualized Return	12.16%
Number of Trades	374
Win Rate	60.16%
Average PnL per Trade	$303.19
Max Drawdown	0.50%

Profit Factor	17.76





The results indicate that the strategy delivers consistent, attractive returns relative to the risk taken, with a solid win rate and manageable drawdowns. Profitability was most pronounced in periods following sharp volatility surges, as anticipated by the design logic.

8. Conclusion and Future Work

This study demonstrates that volatility mean-reversion is a robust, repeatable phenomenon that can be effectively harnessed through a structured options-selling strategy. By combining clear statistical triggers, hedging practices, real-world trading frictions, and layered exit mechanisms, we were able to create a framework that performed consistently across multiple market regimes.

The use of GOOGL as the underlying asset provided sufficient liquidity, event-driven volatility opportunities, and broad applicability of results.

Future Work

While this study used historical spot IV and stock price series to model trades, a natural next step would be to simulate forward stock and volatility paths using a **Heston stochastic volatility model**. This would allow testing of strategy robustness under a fully endogenous volatility process, capturing random shocks and volatility clustering more realistically. Furthermore, extending the framework to dynamically adjust hedge ratios based on gamma or vega exposure could enhance performance during sharp price swings.

9. Additional Illustrations

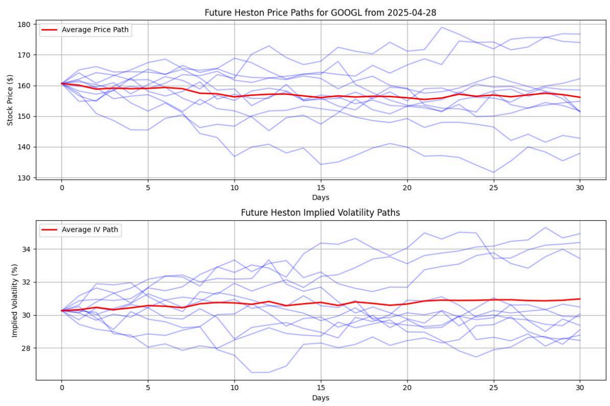


Fig 1. Future Heston Price & IV Paths

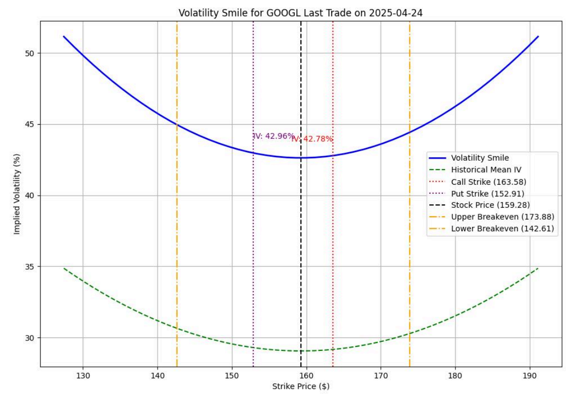


Fig. 2 Volatility Smile for Last Trade

Fig 1. Simulated forward price and implied-volatility trajectories over the 30-day horizon following the last data point, generated via the Heston stochastic-volatility model.
Top panel: Ten individual price paths (light) and their mean (bold red), illustrating the range of possible stock outcomes under mean-reverting volatility dynamics.
Bottom panel: Corresponding IV paths (light) with their average (bold red), showing IV gravitating back toward its long-run level (θ) after the initial spike—underscoring the rationale for selling elevated vol.

Fig 2. Volatility smile on the entry date of the last executed short-strangle trade. The solid curve represents the implied volatilities at each strike, while the dashed line shows the 1-year historical mean IV at corresponding moneyness. Both the call and put strikes lie more than 0.9 σ above their historical averages, confirming the elevated-IV trigger and the asymmetry (put skew > call skew) in our trade selection.