WallStreetQuants

Statistical Arbitrage in Cryptocurrencies

Kevin Tan YueJun

Background

Statistical arbitrage refers to a class of trading strategies that seek to identify systematic patterns in price and volume data that are predictive of future returns. It is among the most widely used and successful approaches employed by quantitative hedge funds.

Given the relative immaturity of cryptocurrency markets, they are likely to offer abundant opportunities for exploiting market inefficiencies through statistical arbitrage methods. In practice, statistical arbitrage strategies primarily capitalize on two types of return patterns: **momentum** and **mean reversion (reversal)**.

2 Classes of Strategies Employed

Cross-Sectional Equal Volatility Rolling Mean Strategy

A momentum-based strategy that cross-sectionally rank and long trading pairs based on their rolling-window mean. The core idea is that assets which outperform their peers over a recent period tend to continue outperforming in the near term, allowing us to long a basket of recent top-performing cryptocurrencies for a fixed holding period.

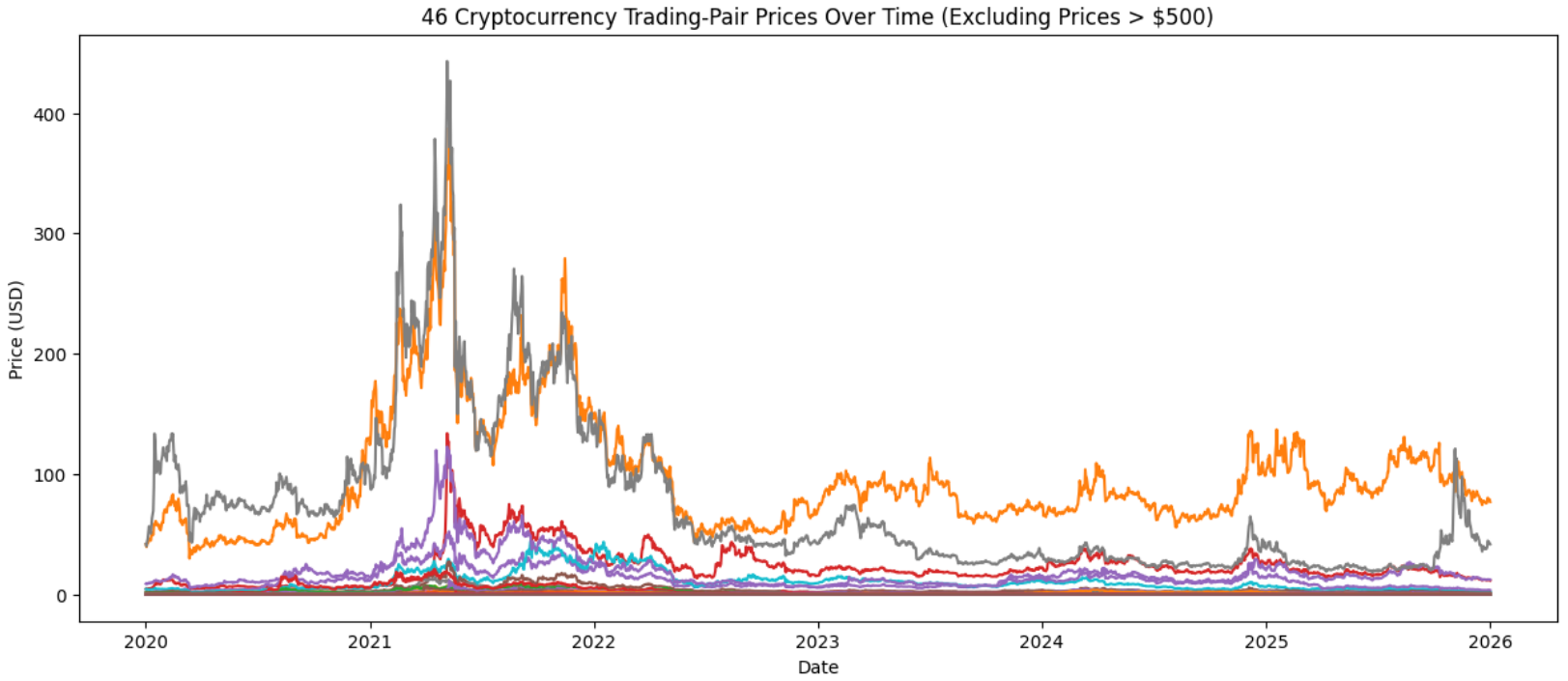
Moving Average Cross-Over Long-Short Equal Volatility Strategy

A momentum-based strategy that takes both long and short positions using a dual moving average framework. Trading signals are generated when a short-term moving average (STMA) crosses a long-term moving average (LTMA).

Specifically, the asset is **longed** when the STMA crosses above the LTMA and **shorted** when the STMA crosses below the LTMA

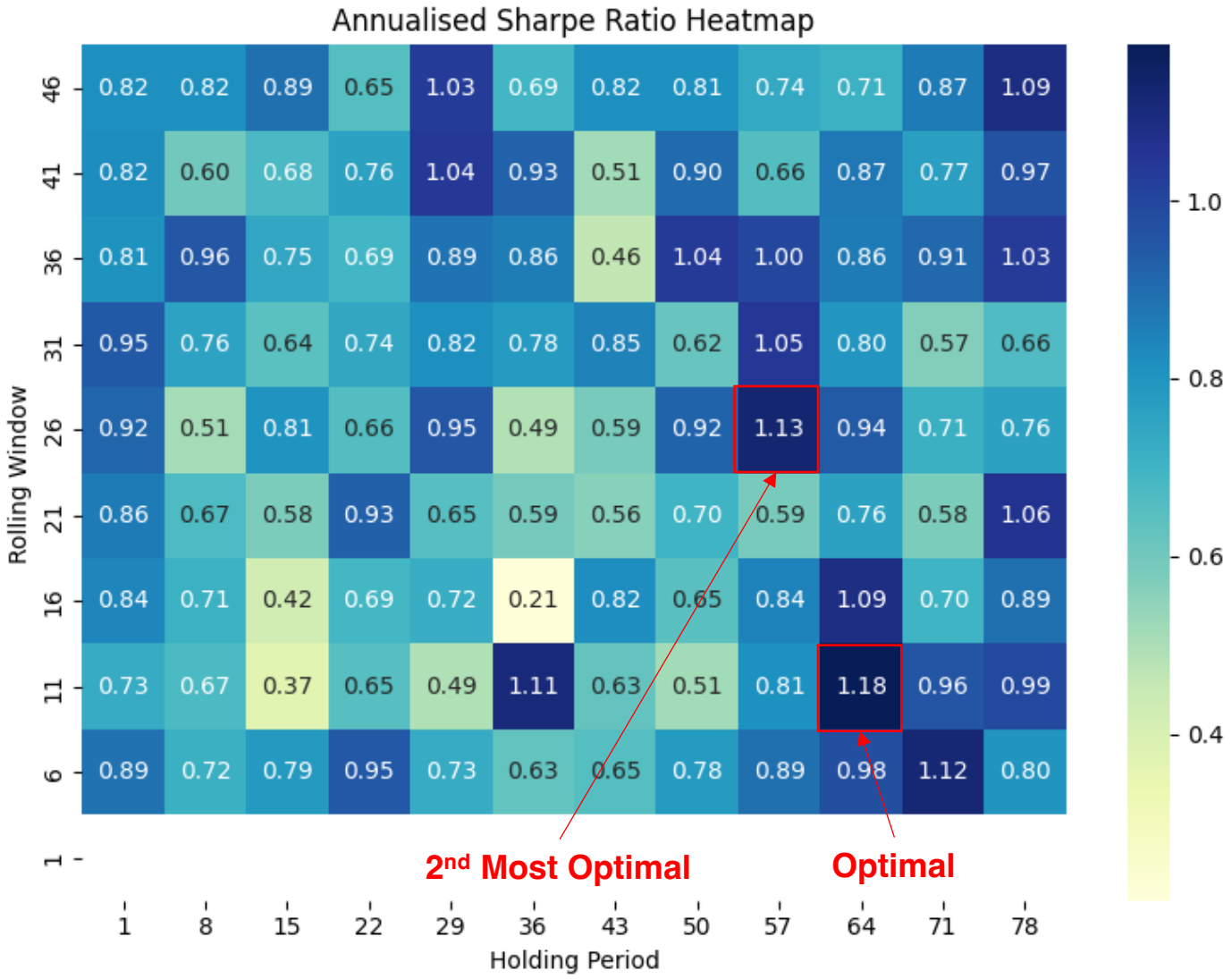
Key Parameters and Data

- Cryptocurrency Trading Pairs (~50 after data cleaning) from Binance API
- Period of analysis: **2020 – 2025**
  - Train (**2020 – 2024**)
  - Test (**2025**)
- Execution Costs
  - Market Orders: **0.2%**
  - Limit Orders: **0.07%**

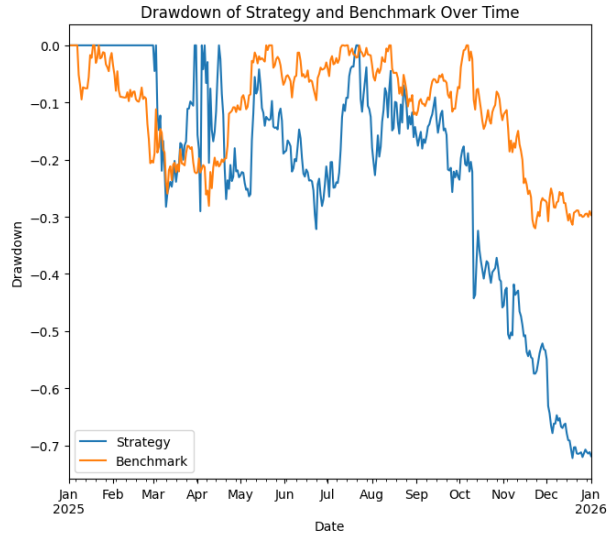


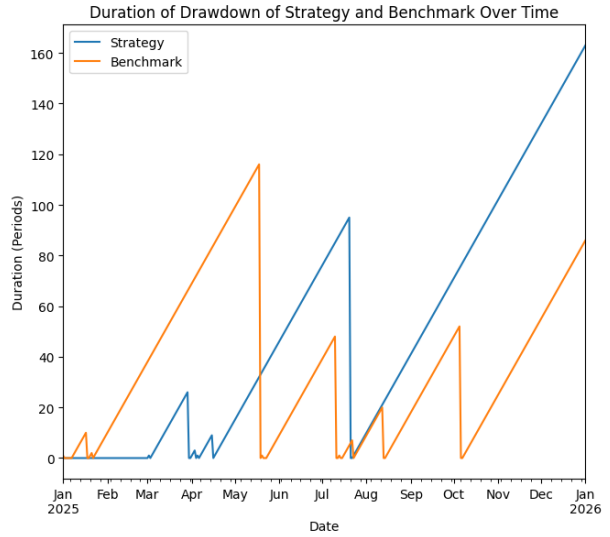
Cross-Sectional Equal Volatility Rolling Mean Strategy

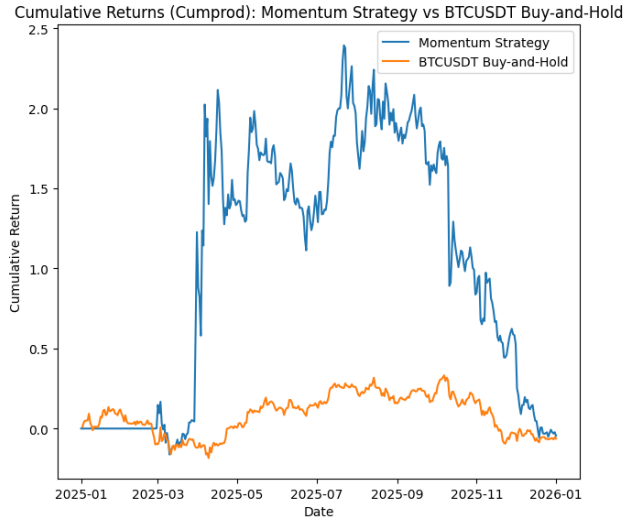
- Grid Search to find the optimal Rolling Mean and Holding Period.
- Iterate over a period of 50 days for rolling window and holding period. For each pair, we will compute the annualized Sharpe Ratio of our strategy on the training data.
- We selected our <u>second</u> most optimal $Rolling\ Mean_{Optimal}$ and $Holding\ Period_{optimal}$ values of 26 and 57, as we would want to avoid having a short rolling window of only 11 days, which we fear might capture too much noise and lead to volatile swings in the short term.

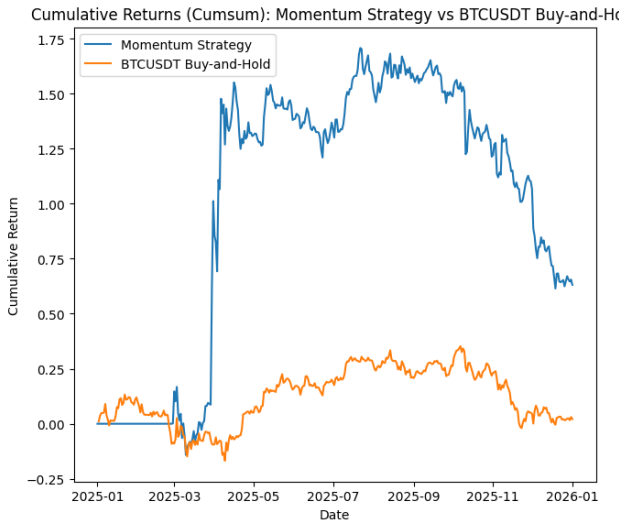


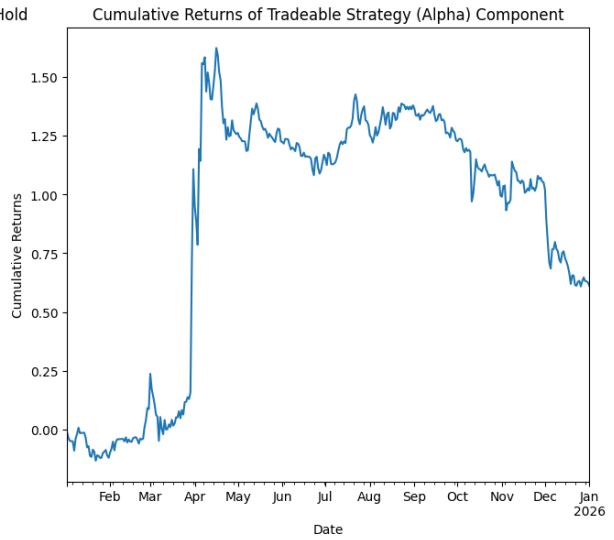
Performance Metrics for Cross-Sectional Equal Volatility Rolling Mean Strategy











Performance Metrics for Cross-Sectional Equal Volatility Rolling Mean Strategy

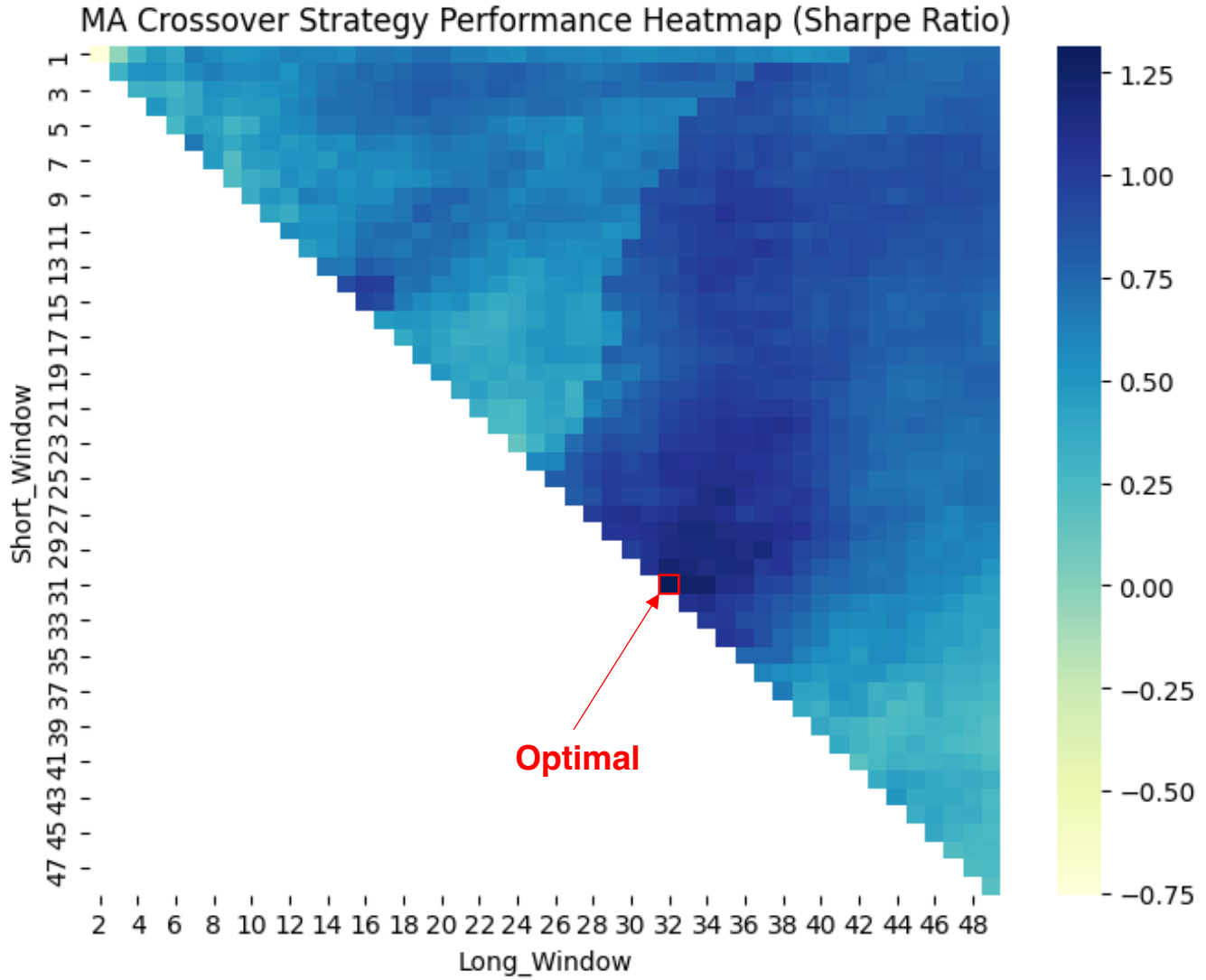
Performance Metrics	Strategy	Benchmark
Annualised Return	*0.543730*	*0.014711*
Annualised Volatility	*1.018845*	*0.346389*
Sharpe Ratio	*0.426538*	*0.042162*
Hit Rate	*0.415301*	*0.500000*
Max Drawdown (%)	*72.22819*	*32.02251*
Max Drawdown Duration (periods)	*163*	*116*

Performance Metrics	Strategy
Alpha	*0.00104734*
Beta	*0.9992*
Information Ratio (IR)	*0.432190*
Alpha t-stat	*0.520136*

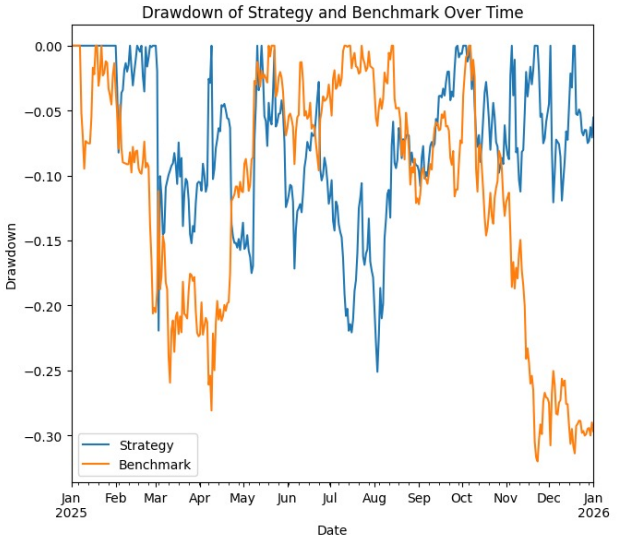
Performance Metrics	Strategy
Average Turnover	*0.022833*
Gross of Transaction Cost Returns	*0.426538*
Net Returns after Transaction Cost	*0.314457*
Annualised Sharpe Ratio after Transaction Cost	*0.415265*

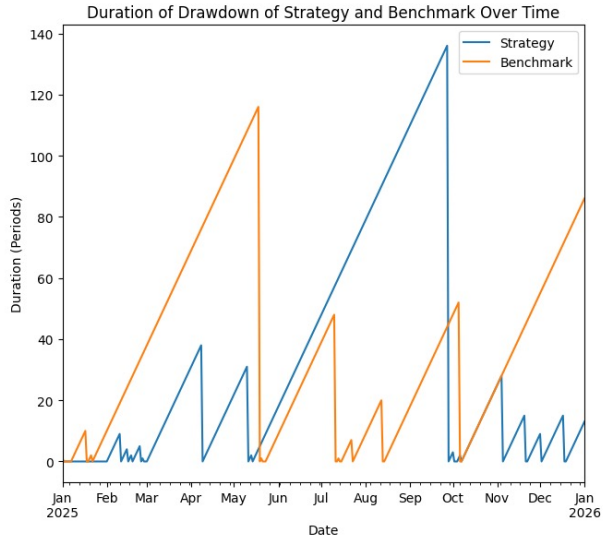
Moving Average Cross-Over Long-Short Equal Volatility Strategy

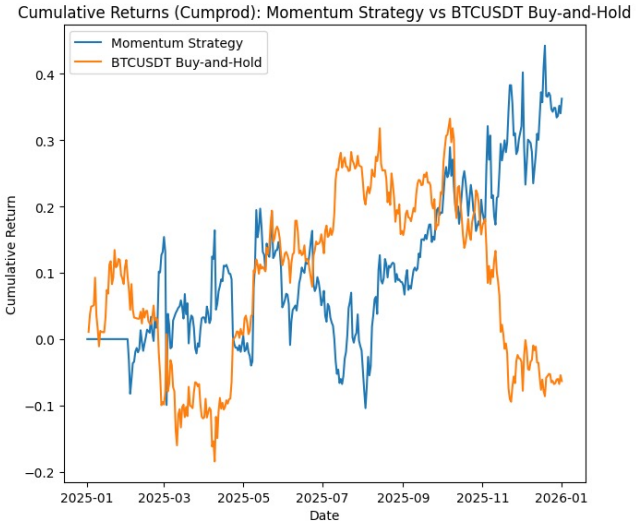
- Grid Search to find the optimal STMA and LTMA lookback periods.
- Iterate over a period of 50 days for STMA and LTMA. For each pair, we will compute the annualized Sharpe Ratio of our strategy on the training data.
- We selected our most Sharpe Ratio optimal $STMA_{Optimal}$ and $LTMA_{optimal}$ values of 31 and 32.

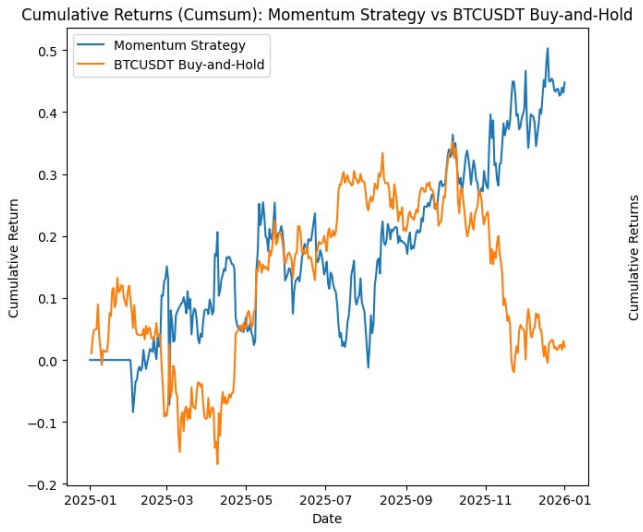


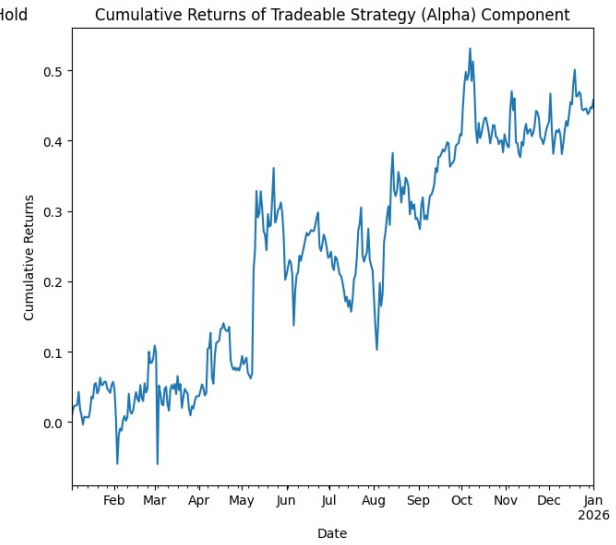
Performance Metrics for Moving Average Cross-Over Long-Short Equal Volatility Strategy

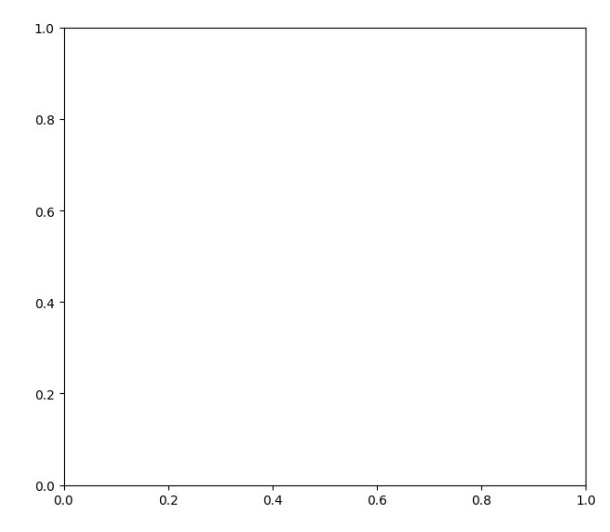






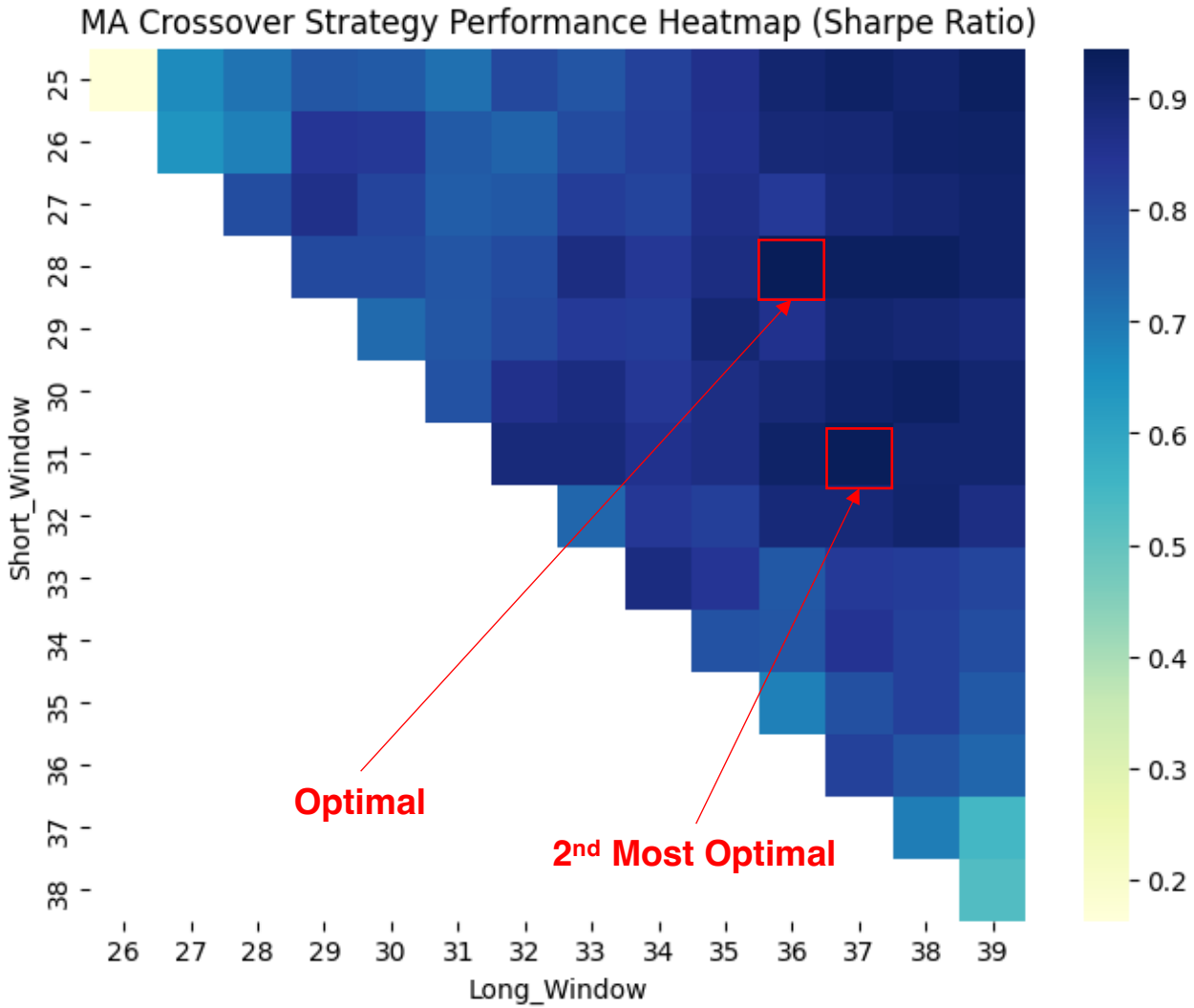




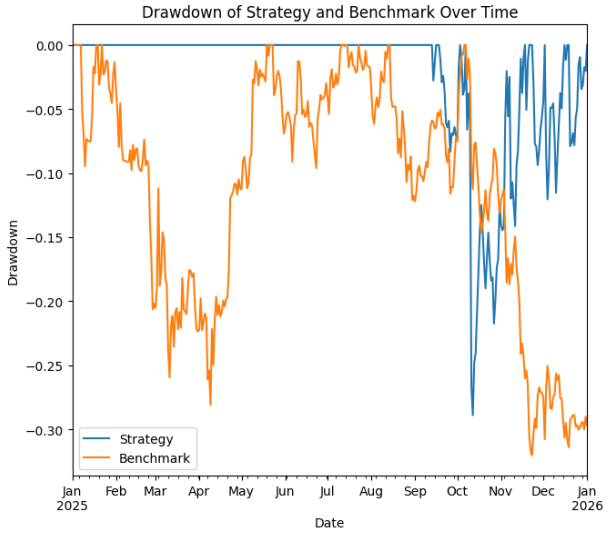


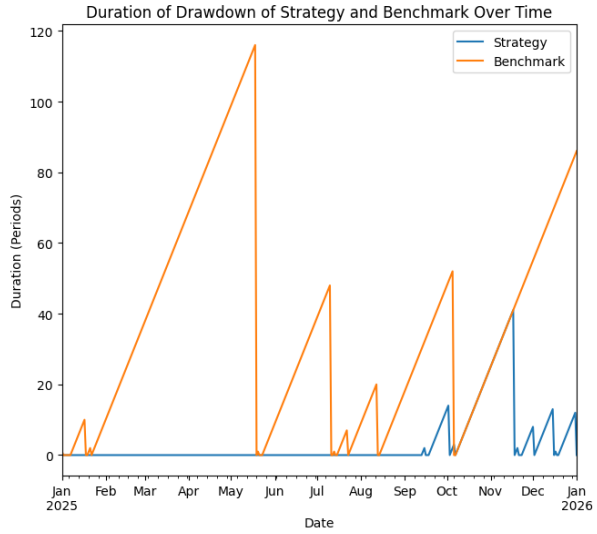
Moving Average Cross-Over Long-Short Equal Volatility Strategy

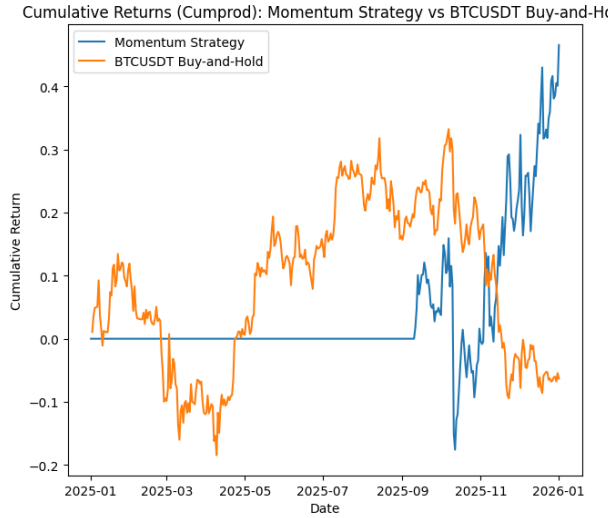
- As part of our strategy enhancement, we incorporated the equal volatility component for our portfolio allocation.
- Grid Search to find the optimal STMA and LTMA lookback periods.
- Iterate over a smaller range of 25-40 days for STMA and LTMA. For each pair, we will compute the annualized Sharpe Ratio of our strategy on the training data.
- We selected our 2nd most Sharpe Ratio optimal $STMA_{Optimal}$ and $LTMA_{optimal}$ values of 31 and 37.

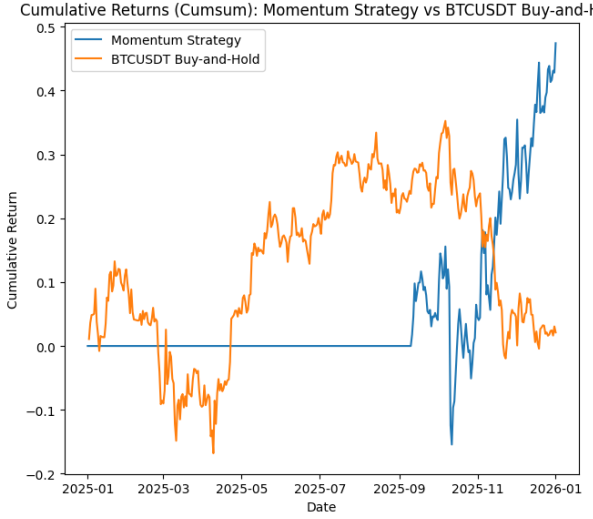


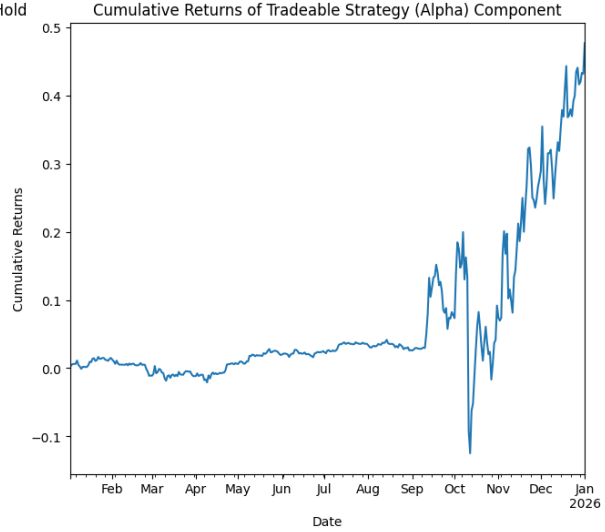
Performance Metrics for Moving Average Cross-Over Long-Short Equal Volatility Strategy











Performance Metrics for Moving Average Cross-Over Long-Short Equal Volatility Strategy

Performance Metrics	Strategy	Benchmark
Annualised Return	*0.385679*	*0.014711*
Annualised Volatility	*0.347875*	*0.346389*
Sharpe Ratio	*0.938273*	*0.042162*
Hit Rate	*0.185792*	*0.500000*
Max Drawdown (%)	*29.90982*	*32.02251*
Max Drawdown Duration (periods)	*41*	*116*

Performance Metrics	Strategy
Alpha	*0.00130529*
Beta	*-0.1243*
Information Ratio (IR)	*0.952866*
Alpha t-stat	*1.1467629*

Performance Metrics	Strategy
Average Turnover	*0.0200206*
Gross of Transaction Cost Returns	*0.9382732*
Net Returns after Transaction Cost	*0.459389*
Annualised Sharpe Ratio after Transaction Cost	*0.91066*

Strategy Limitations

- **Regime Sensitivity & High Volatility**

Momentum performs poorly in sideways or mean-reverting markets. Sudden trend reversals increase return volatility, reducing the Sharpe Ratio despite positive cumulative returns.

- **Lack of Dynamic Risk Control**

No adjustment to leverage or exposure during drawdowns. Risk remains similar across calm and volatile periods, resulting in high drawdowns and inefficient risk allocation.

- **Simplistic Signals & Weighting**

Rolling-window momentum and equal-volatility weighting ignore cross-asset correlations, nonlinear effects, and signal strength, limiting diversification and risk-adjusted performance.

Future improvements

- **Enhanced Risk Allocation**

Replace equal-volatility weighting with correlation-aware approaches (e.g. risk parity, minimum-variance) to improve diversification and reduce concentration risk, especially during market stress.

- **Downside-Risk-Focused Optimisation**

Optimise using downside risk metrics such as maximum drawdown, CVaR, or Sortino Ratio rather than Sharpe alone. Incorporate drawdown-based stop-loss rules to better protect capital.

- **Dynamic Lookback & Holding Periods**

Allow rolling windows and holding periods to adapt to changing market regimes, improving responsiveness while reducing reliance on fixed parameters.