Analysis of Trading Strategies

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Agenda

01 Introduction

02 Data Exploration

03 Methodology

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05 Conclusion & Future Work

Introduction

Trading Bot Functionality:

- Trading Bot functionality is now complete.
- With this milestone achieved, we are ready to implement and test actual trading strategies.

MACD & Dynamic RSI Strategy Experiments:

- Initiated experiments focusing on a MACD & Dynamic RSI strategy.
- This detailed report covers the experiments, analysis, and insights derived from these strategies.

Introduction

Algorithmic Trading & Technical Indicators:

- Automated trade execution using quantitative models.
- **MACD:** Identifies trends by comparing moving averages.
- **RSI & Dynamic RSI:** Measures momentum and adjusts thresholds based on market volatility.

Motivation & Objectives:

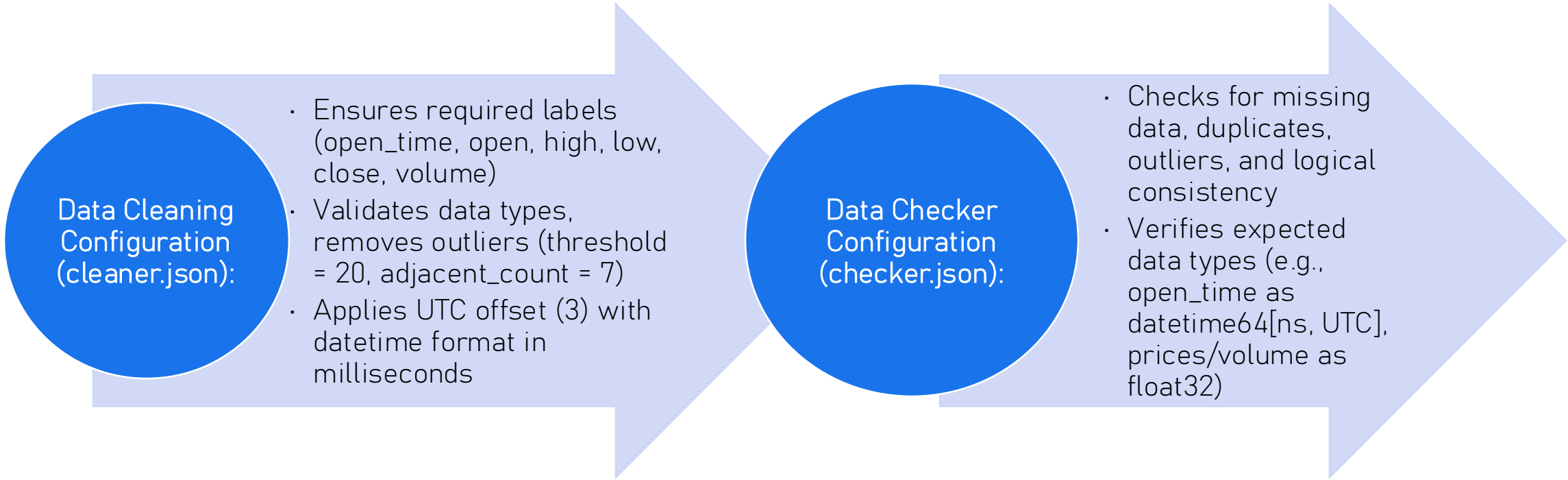
- Optimize parameters for improved performance.
- Validate strategy robustness through comprehensive backtesting.

Data Exploration

DATA CLEANING & CHECKING

FEATURE ENGINEERING

Data Cleaning & Checking Configurations



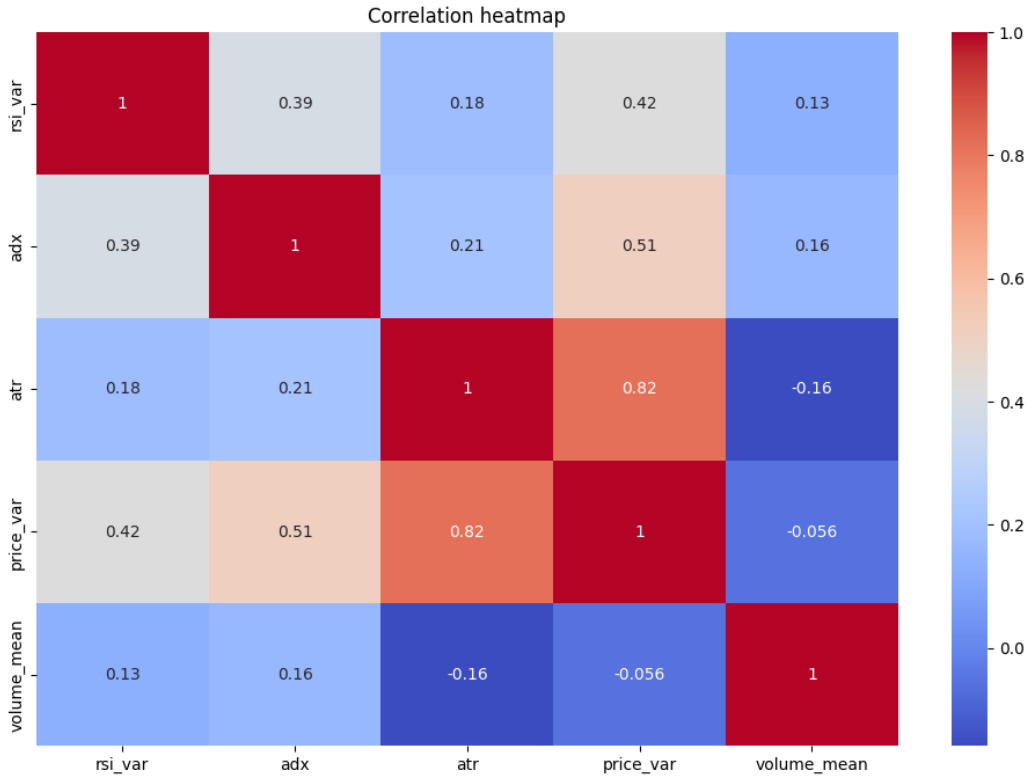
Data Exploration Overview

- Data Source & Timeframe:
  - BTCUSDT data from Jan 2023 to Sep 2024 (15-minute intervals)
- Feature Extraction:
  - Used SingleSymbolDataHandler & SingleSymbolFeatureExtractor
  - Key indicators: RSI, MACD (and its components), Stochastics, Bollinger Bands, ATR, VWAP, OBV, SMA, EMA, ADX, plus ‘close’ & ‘volume’

Derived Features & RSI Variance Analysis

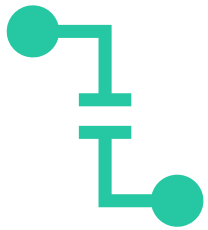
- RSI Variance & Range:
  - Calculated rolling RSI variance (window = 15)
  - Computed rolling RSI min & max (window = 30) to assess range
- Price Volatility:
  - Rolling standard deviation of close prices (window = 15)
- Insight:
  - Larger RSI variance (wider range) motivates the development of a dynamic RSI model to adapt thresholds in real-time

Correlation Heatmap with RSI variance



- **Correlation Analysis:**Scaled indicators using MinMaxScaler for uniformity
- Correlations observed among RSI-derived metrics (e.g., rsi_max, rsi_min, rsi_var)
  - Medium: price variance, adx
  - Small: ATR, Volume(rolling mean)

Implications & Dynamic RSI Model Development



Dynamic RSI Motivation:

Observed large variance in RSI supports dynamic adjustment of thresholds

Aims to adapt overbought/oversold levels based on current market volatility

Expected Benefits:

Improved signal responsiveness in sideways markets

Better risk management by reducing false signals and capturing market nuances

Methodology

OVERALL SETUP & DATA CONFIGURATION

STRATEGY OVERVIEWS

EXPERIMENTAL PROCESS & EVALUATION

OVERALL SETUP & DATA CONFIGURATION

- Tools & Environment:
  - Python libraries (pandas, NumPy, matplotlib, scikit-learn, etc.)
  - Custom modules for data handling and feature extraction
  - Automated data cleaning via the trading bot (detailed later)

OVERALL SETUP & DATA CONFIGURATION

Data & Timeframe:

- Symbol: BTCUSDT
- Interval: 15 minutes
- Example Date Ranges: 2023–2024 for initial tests; 2024–2025 for untouched data

Feature Set Parameters (from feature_set_15m.json):

- RSI period: 3
- MACD: short=15, long=30, signal=20
- Additional indicators: Stochastics, Bollinger Bands, ATR, VWAP, OBV, SMA, EMA, ADX, etc.

Strategy Overviews

- Strategy 1: MACD Histogram with Threshold
  - Compute MACD histogram (macd_diff)
  - **Buy:** When macd_diff > threshold
  - **Sell:** When macd_diff < –threshold
  - Full capital invested; performance metrics computed

Strategy Overviews

- Strategy 2: MACD with Trend Confirmation
  - Combine MACD signals with ADX for trend validation
  - **Buy**: When macd_diff > threshold **and** ADX **≥** 45
  - **Sell**: When macd_diff < –threshold while ADX confirms trend

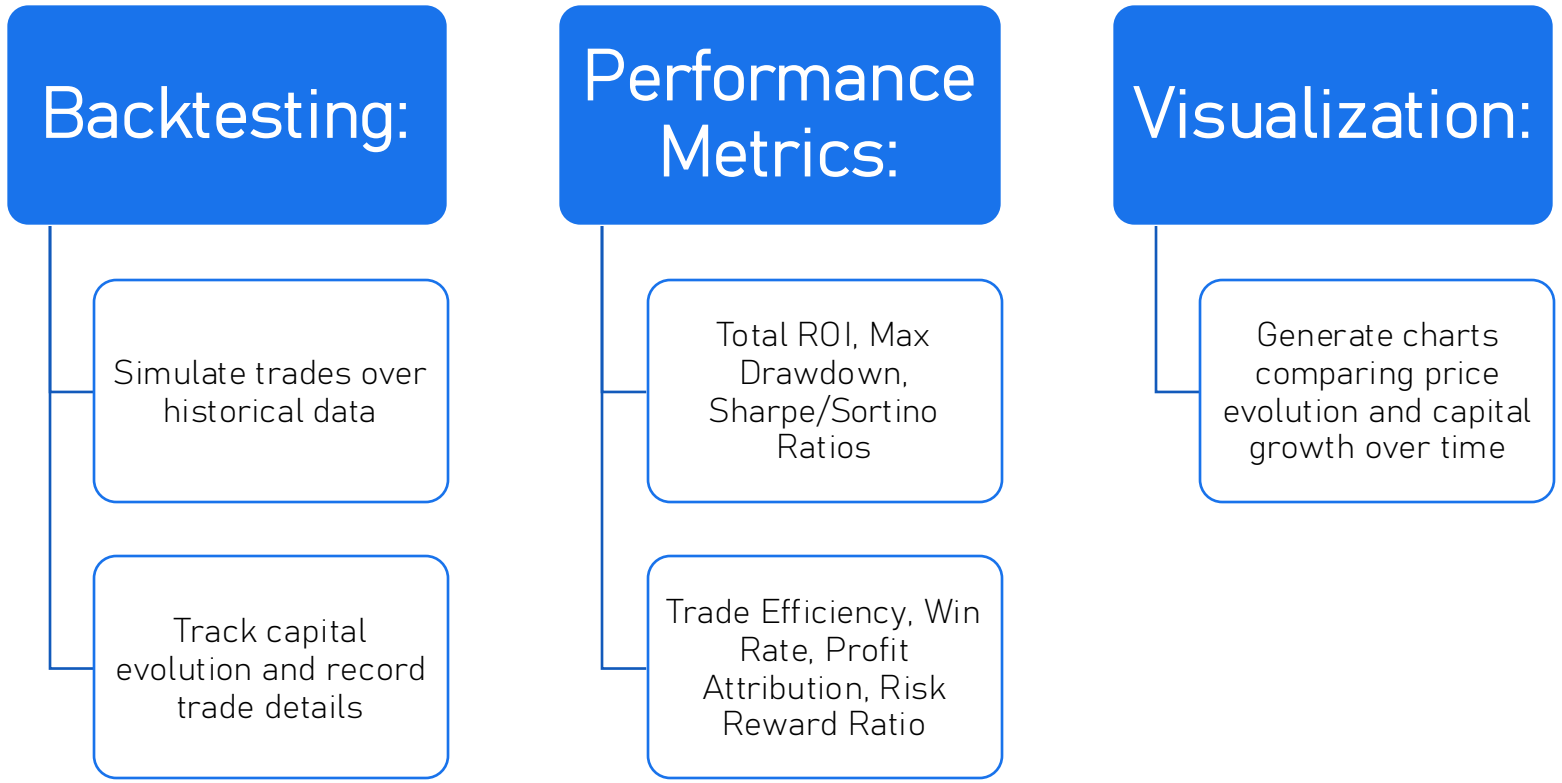
Strategy Overviews

- Strategy 3: Dynamic RSI on Sideways Markets
  - Active only when market is non-trending (ADX below threshold)
  - Calculate dynamic RSI thresholds using rolling mean and standard deviation
  - **Buy:** When RSI falls below the dynamic lower boundary
  - **Sell:** When RSI rises above the dynamic upper boundary

Strategy Overviews

- Strategy 4: Combined Strategy (Dynamic RSI + MACD)
  - Regime-based approach using ADX:
    - **Dynamic RSI Regime:** When ADX < rsi_trend_threshold (≈20–23)
    - **MACD Regime:** When ADX > adx_macd_threshold (≈45)
    - **Undefined Region:** Optionally use SSTI to trigger exits
  - Integrates benefits of both strategies while addressing conflicts and noise

Experimental Process & Evaluation

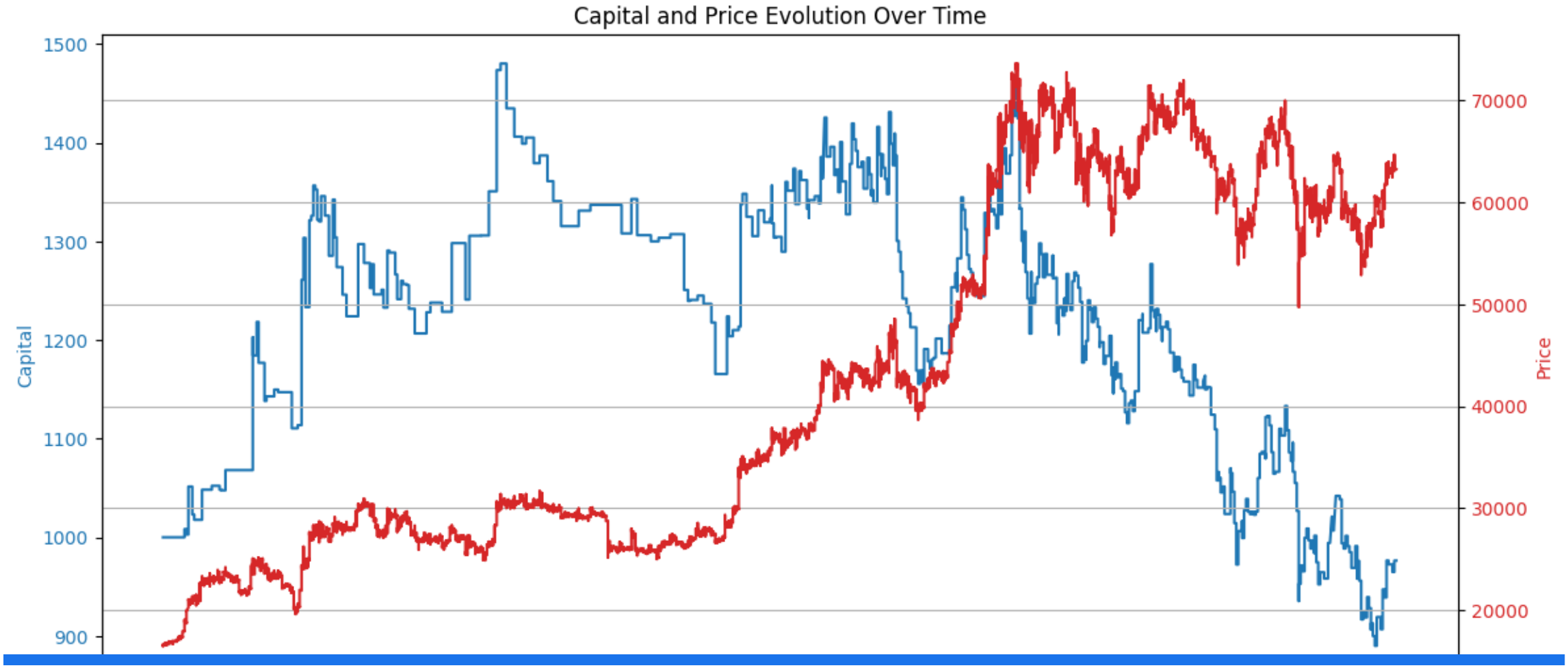


Strategy Performance Overview

OVERALL SETUP & DATA CONFIGURATION

STRATEGY OVERVIEWS

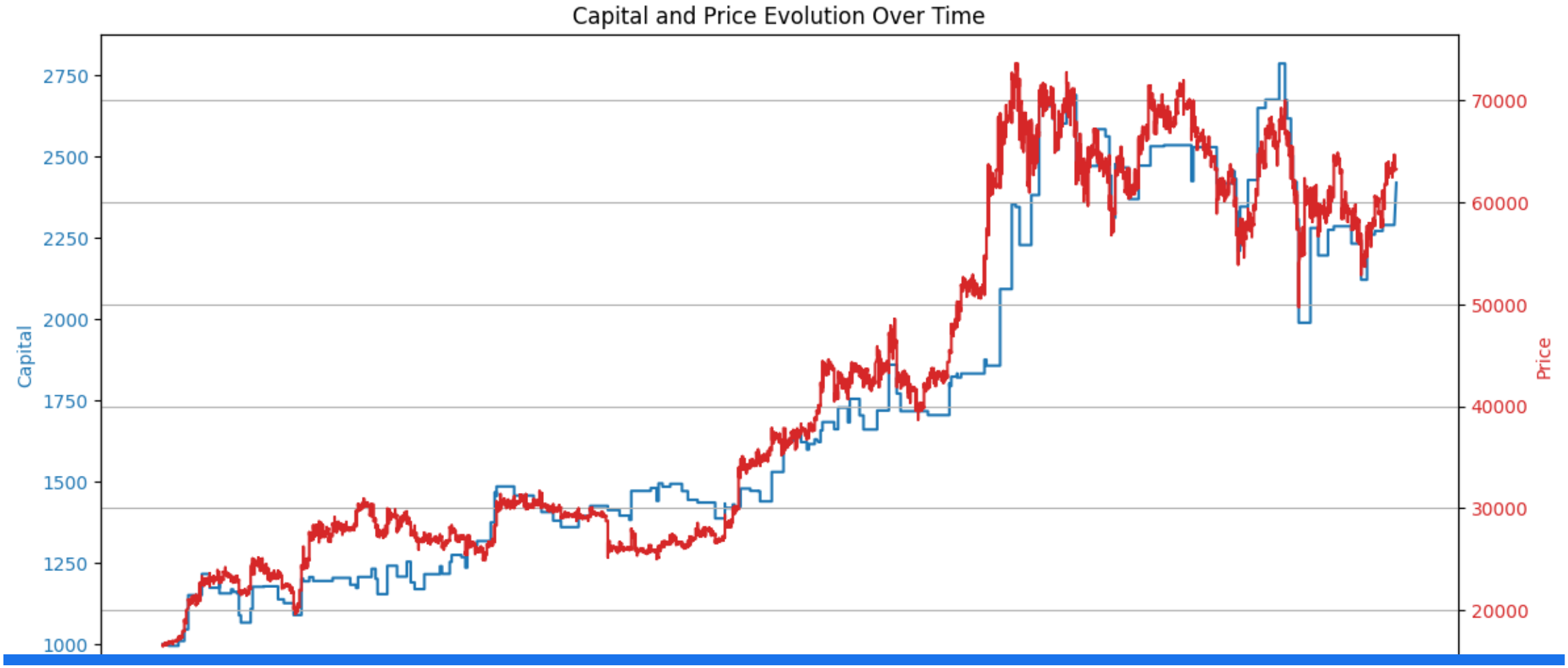
EXPERIMENTAL PROCESS & EVALUATION



Strategy Performance

Strategy 1: MACD Histogram with Threshold

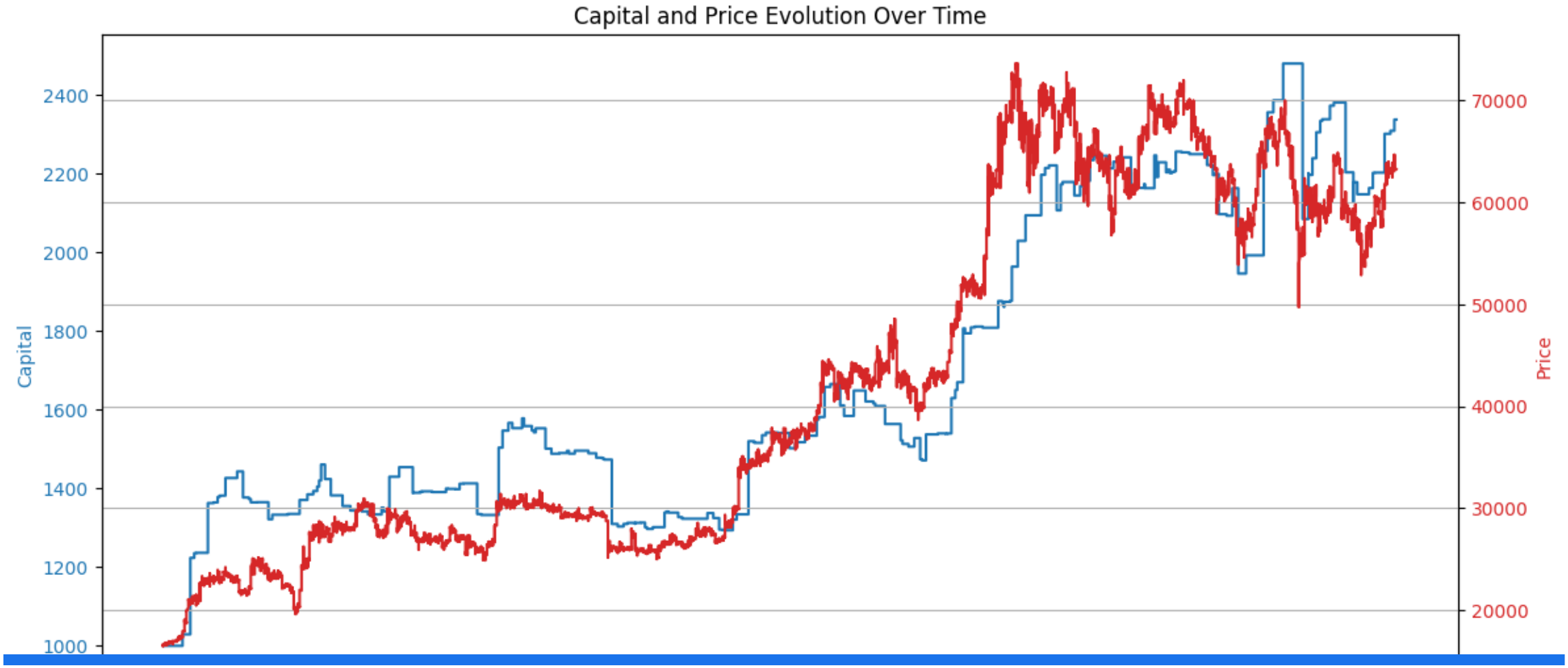
- ROI: ~ -2.36%
- Max Drawdown: ~39.87%
- Note: Despite a high underlying asset gain (Symbol ROI ~282.88%), frequent trades and noise lead to negative overall performance.



Strategy Performance

Strategy 2: MACD with Trend Confirmation

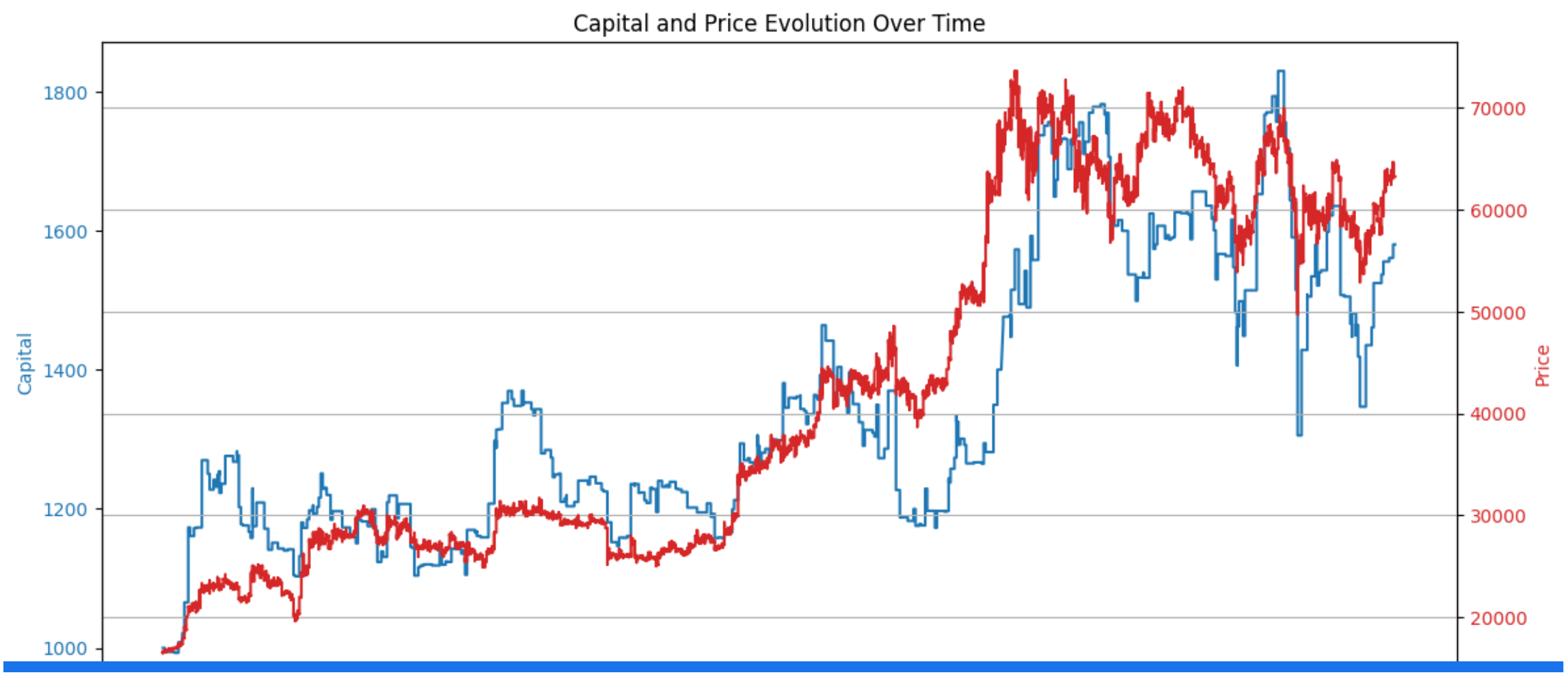
- ROI: ~142%
- Max Drawdown: ~28.64%
- ADX filter (threshold ≥45) improved performance by excluding trades in non-trending periods.



Strategy Performance

Strategy 3: Dynamic RSI on Sideways Markets

- ROI: ~133.73%
- Max Drawdown: ~18.04%
- Higher win rate (~57%) due to adaptive RSI thresholds that adjust to market volatility.

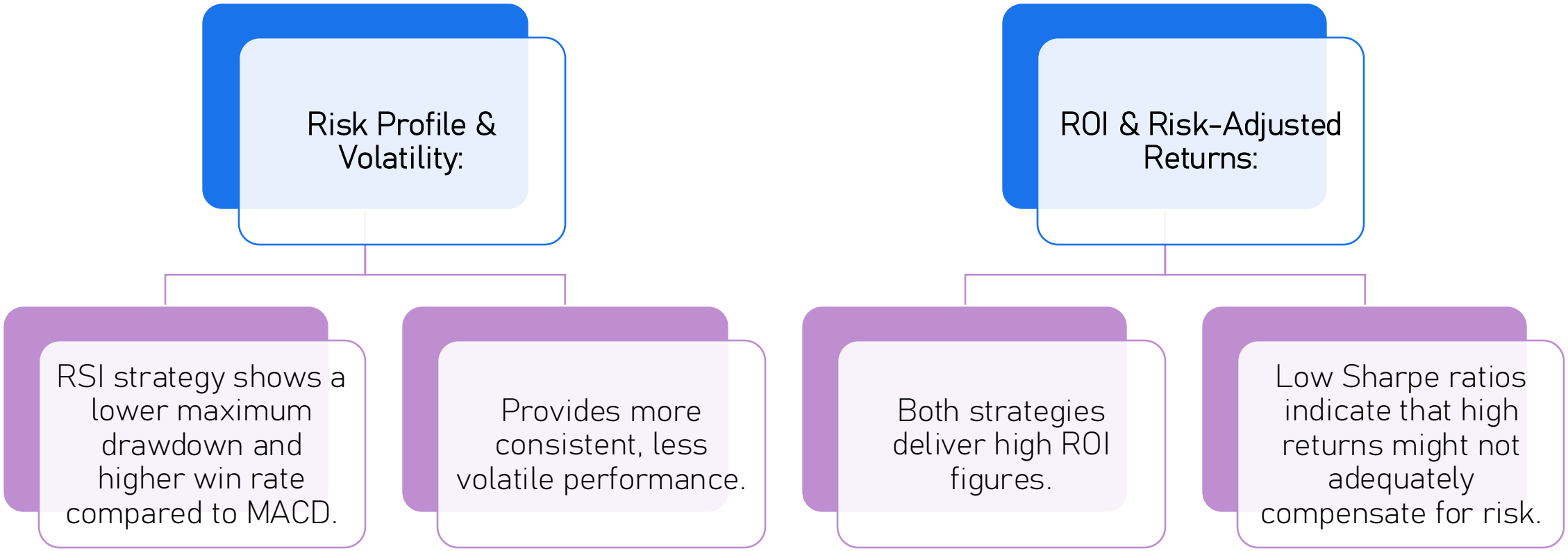


Strategy Performance

Strategy 4: Combined Strategy (Dynamic RSI + MACD)

- Mixed outcomes:
  - Variant 1: ROI ~58%
  - Variant 2 (with SSTI exit): ROI ~5.29%
- Complexity may cause signal conflicts and potential overfitting.

Comparative Analysis

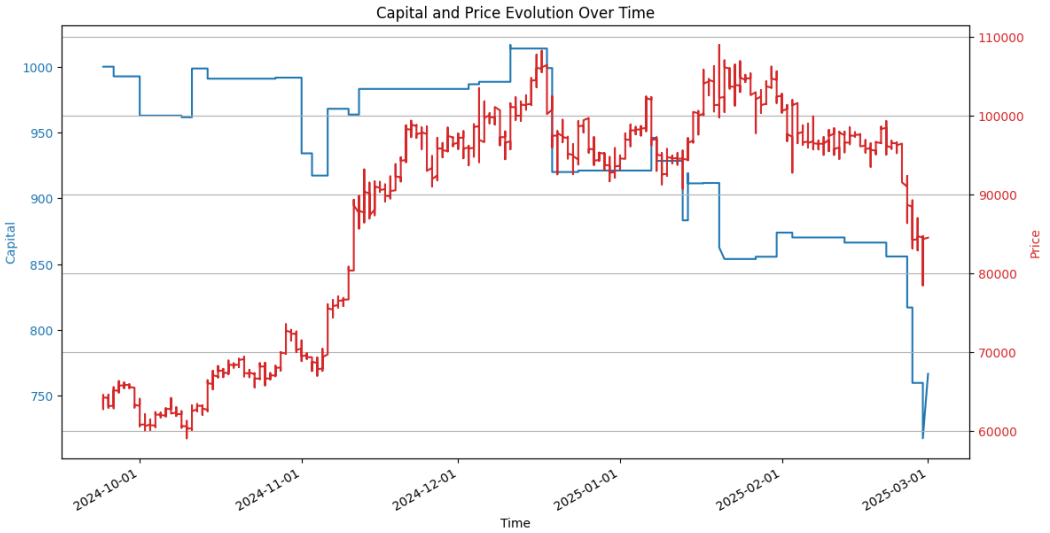


Comparative Analysis

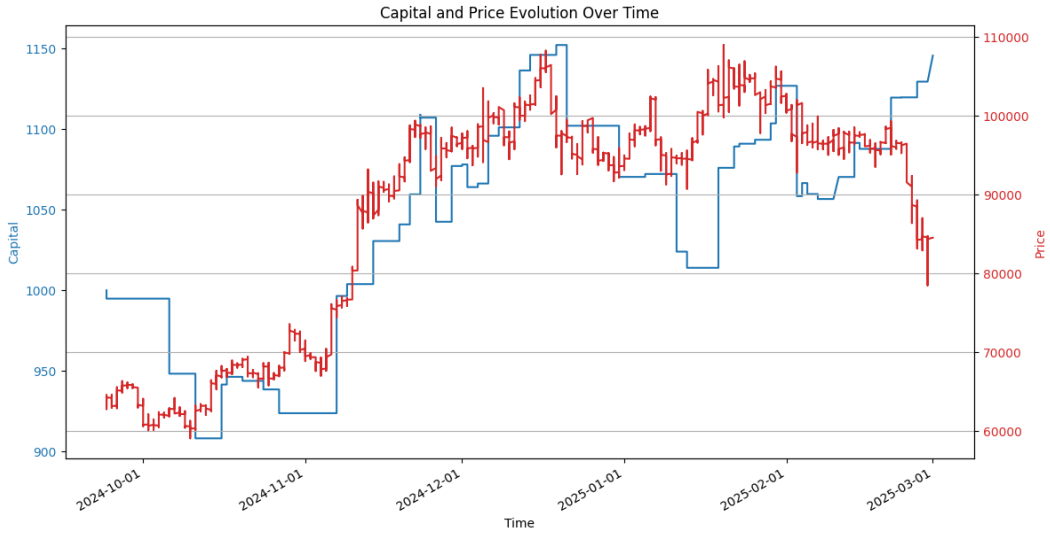
- Trade Efficiency & Robustness:
  - RSI strategy offers better trade efficiency.
  - RSI models are more robust under fine tuning, enhancing performance stability.
- Overall Effectiveness:
  - Despite slightly lower ROI, the improved drawdown profile, higher win rate, and robustness make the RSI strategy potentially more attractive for risk-conscious traders.
  - Balancing profit capture with loss control is key to long-term trading success.

Back test on Unseen Data – Robustness

MACD + ADX CONFIRMATION



RSI + ADX CONFIRMATION



More Attempts on Dynamical RSI

MOTIVATED BY THE DISCOVERY

MACHINE LEARNING ON RSI THRESHOLDS

ALTERNATIVE DYNAMICAL THRESHOLD MODEL

Random Forest Modeling for RSI Thresholds

Target: Predict dynamic RSI max and min using features explored (price variance, adx, atr, volume mean, etc.)

Validation: TimeSeriesSplit & GridSearchCV (R^2 ~0.78 with MSE around 2.72)

Observation: RF predictions are similar to simple rolling window values.

Alternative Dynamic Threshold Methods

Median-Based Adjustment:

Use historical median with margin (mae) adjustments.

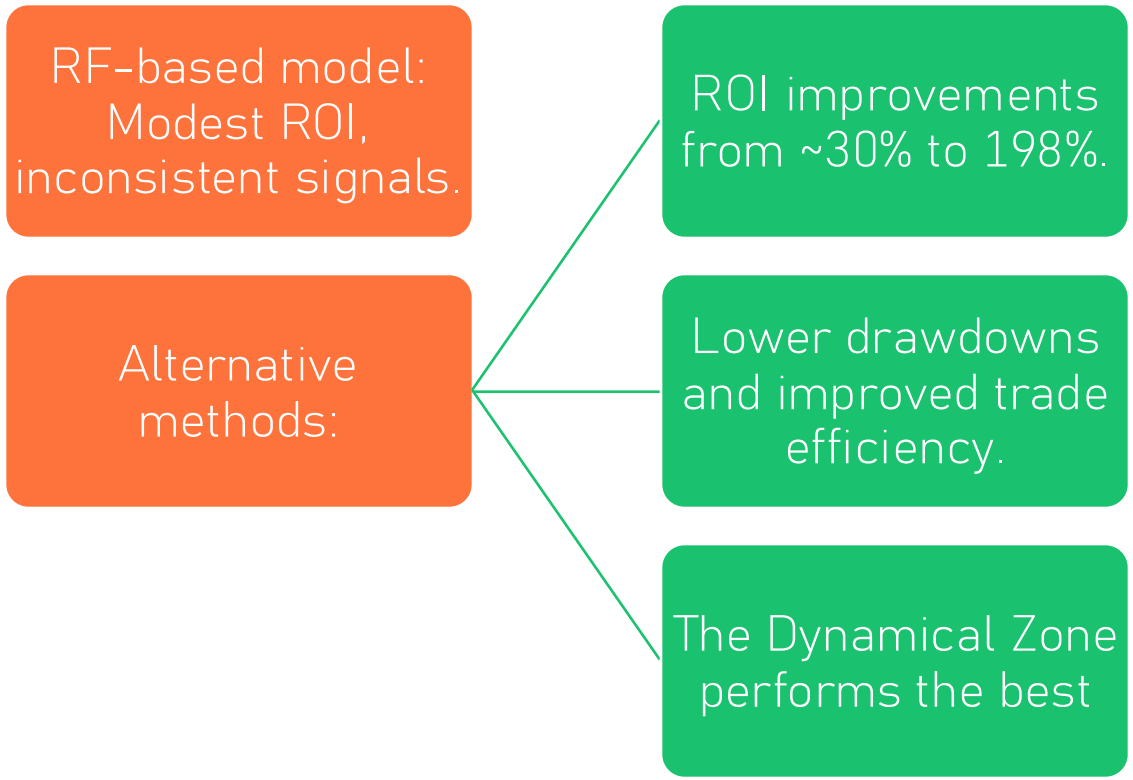
Dynamic Zone Approach:

Rolling RSI mean ± k * standard deviation (clipped within realistic RSI limits).

Volatility-Linked Model:

Adjust thresholds based on ATR and price variation.

Trading Strategy Performance



Using The Backtest Module

TO MIMIC THE REAL-TIME TRADING ENVIRONMENT

TESTING ROBUSTNESS OF STRATEGIES

Overview

To reflect real-world trading conditions more accurately than an idealized backtest:

- **Maximum Window Storage:** Limits on historical data storage.
- **Incremental Calculation:** Real-time updating of indicator values.
- **Rounding of Amounts:** Values are rounded to three digits (an empirically chosen setting for cryptocurrency volatility) to mitigate issues caused by lag-induced price fluctuations.

RSI+ADX Strategy Performance Comparison

REAL-TIME MIMIC RESULTS

- ROI: 154.40%
- Max Drawdown: 17.08%
- Sharpe Ratio: 0.00909
- Win Rate: 14.16%
- Profit Factor: 1.626
- Avg Trade Return: 8.99%

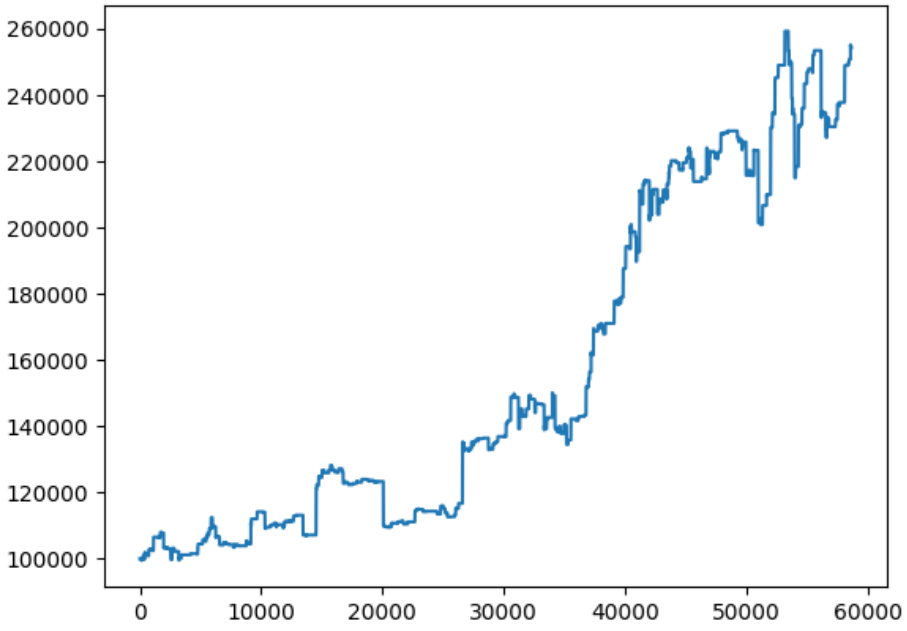
IDEAL NOTEBOOK RESULTS

- ROI: 133.73%
- Max Drawdown: 18.04%
- Sharpe Ratio: 0.00807
- Win Rate: 57.29%
- Trade Efficiency: 20.57%

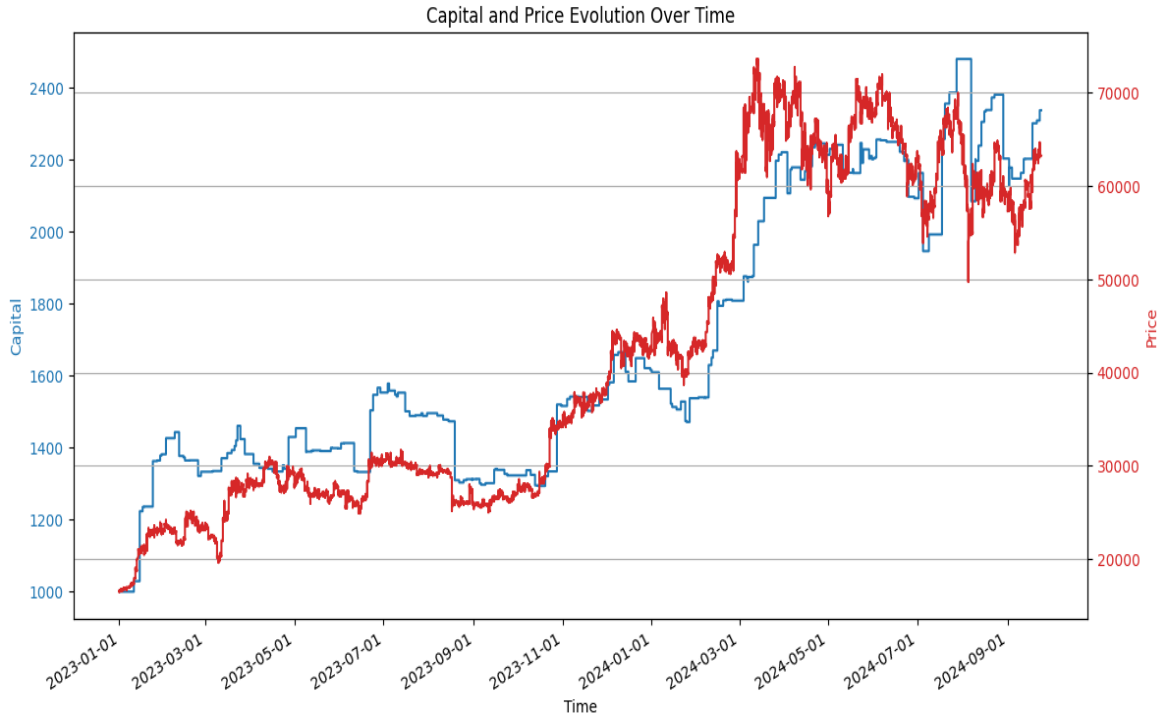
- Observations: Comparable ROI and drawdowns indicate **robustness.**
- The discrepancy in win rate may reflect execution differences (there are small trades opened due to the rounding).

RSI+ADX Strategy Performance Comparison

REAL-TIME MIMIC RESULTS



IDEAL NOTEBOOK RESULTS



MACD+ADX Strategy Performance Comparison

REAL-TIME MIMIC RESULTS

- ROI: 81.51%
- Max Drawdown: 26.20%
- Sharpe Ratio: 0.00564
- Win Rate: 17.26%
- Profit Factor: 1.391
- Avg Trade Return: 20.83%

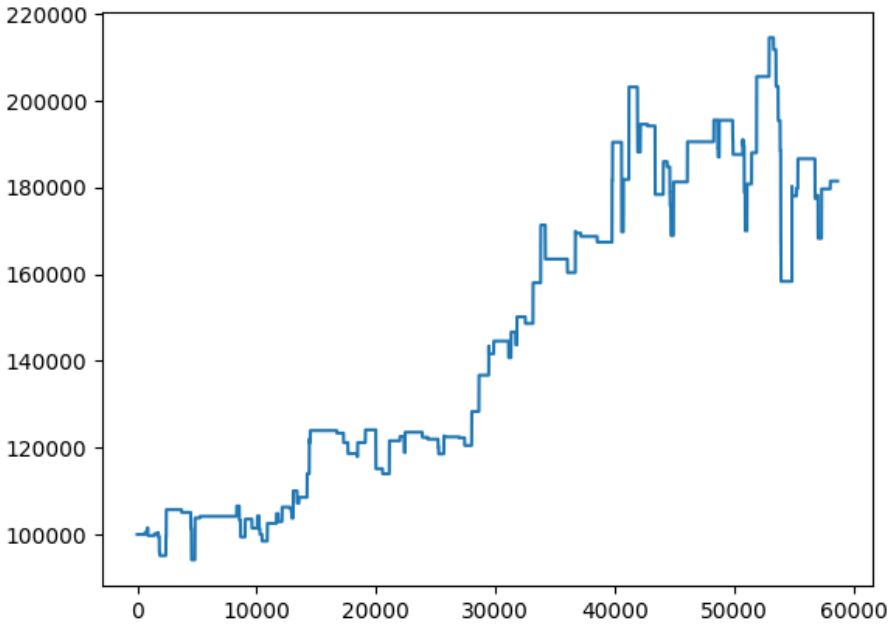
IDEAL NOTEBOOK RESULTS

- ROI: 142.00%
- Max Drawdown: 28.64%
- Sharpe Ratio: 0.00817
- Win Rate: 44.74%
- Trade Efficiency: 15.83%

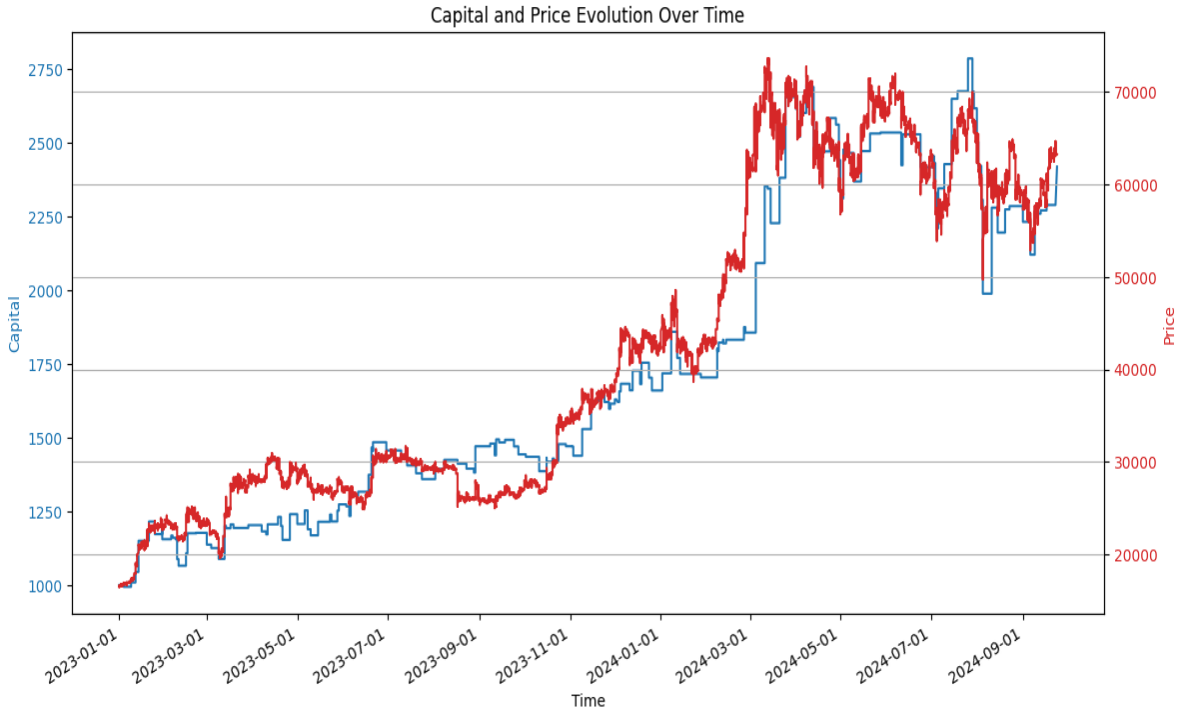
- Significant performance drop in real-time mimic.
- MACD+ADX appears more sensitive to incremental updates and rounding.

RSI+ADX Strategy Performance Comparison

REAL-TIME MIMIC RESULTS



IDEAL NOTEBOOK RESULTS



Comparative Analysis

RSI+ADX Strategy:

- Robust performance across environments.
- Slight differences in win rate; overall high ROI and low drawdown.

MACD+ADX Strategy:

- Strong in ideal tests, but affected by real-time constraints.
- Lower ROI and win rate in real-time simulation.

General Insights:

- Real-time mimic simulates practical constraints (window storage, incremental calculation, rounding).
- Highlights the need for strategy optimization under live conditions.

Conclusion & Future work

TO MIMIC THE REAL-TIME TRADING ENVIRONMENT

TESTING ROBUSTNESS OF STRATEGIES

Key Findings & Strategy Insights

RSI+ADX Strategy:

- Robust performance across both ideal and real-time environments.
- Consistent ROI with lower maximum drawdown.
- Better risk management and adaptability through dynamic thresholds.

MACD+ADX Strategy:

- Strong performance in ideal backtests.
- Sensitive to real-time constraints (incremental updates, rounding), leading to reduced ROI and win rate.

Dynamic RSI Models:

- Machine Learning (Random Forest) shows okay R^2 but does not work well on backtesting.
- Simpler statistical methods (median-based, dynamic zones, volatility-linked) often yield competitive or superior results.

Implications for Live Trading

Real-Time Adaptation:	Incremental calculation and limited window storage mimic live conditions. Rounding of trade amounts (3-digit precision) reduces execution noise.
Strategy Suitability:	RSI+ADX proves more robust and effective for live trading. MACD+ADX may need further optimization to overcome real-time execution challenges.

Limitations & Future Directions

Model Sensitivity:

- ML models are sensitive to small target scales; simpler methods may be more practical.
- MACD+ADX strategy's performance drops under real-time conditions.

Future Work:

- Refine hyperparameters and explore ensemble methods.
- Expand testing to multi-asset portfolios and varied market regimes.
- Integrate with live market data for further validation.

Final Conclusion

Dynamic RSI models that adapt to market volatility offer improved risk management.

RSI+ADX strategy emerges as a robust candidate for real-world trading.

Testing under realistic conditions is crucial to ensure strategies perform well live.

Future research will focus on optimizing strategies and mitigating real-time execution issues.

Future Works

Invent Customized Indicators:

- Develop bespoke indicators tailored to specific market regimes.
- Combine traditional technical indicators with novel measures (e.g., sentiment, liquidity, and order flow).

Enhance Machine Learning Models:

- Adapt ensemble methods (e.g., boosting, bagging) to predict dynamic RSI thresholds more robustly.
- Explore deep learning architectures (e.g., LSTM networks) for capturing temporal dependencies.

Future Works

Expand to Multi-Asset Portfolios:

- Extend dynamic RSI models to multi-asset or sector-based strategies.
- Incorporate cross-market correlations to optimize risk and diversification.

Integrate Alternative Data Sources:

- Include alternative data (news sentiment, social media signals, blockchain metrics) to refine indicator thresholds.
- Use real-time economic and financial data feeds to adapt strategies dynamically.

Future Works

Robust Risk Management

- Investigate adaptive stop-loss and take-profit mechanisms integrated with dynamic indicators.
- Develop risk-adjusted performance metrics that account for transaction costs and slippage.

Backtesting & Simulation Enhancements

- Incorporate realistic transaction cost models and slippage.
- Implement simulation frameworks that allow for stress testing under extreme market conditions.