Advanced ML-Based Quantitative Hybrid Trading Strategy(Proposal)

Vanessa Cheung Ji Sung Han Dong Wang Tianyu Zhang

Introduction

This project develops a hybrid trading strategy that integrates technical indicators, risk management, and economic event-based analysis to optimize trading signals. By dynamically adapting parameters based on historical Sharpe Ratio and Win/Loss Ratio, our approach aims to maximize profitability while ensuring stability across different market conditions. We will implement this strategy using Python and R.

Data Selection

We collect data from sources such as Factset and Yahoo Finance, including stock prices and macroeconomic indicators across weekly, monthly, and yearly intervals. To ensure accuracy and robustness, we preprocess the data by normalizing price movements and incorporating outliers into the risk function instead of simple removal.

Stock Selection

We select stocks based on volatility and sensitivity to economic events:

- **High Volatility and Event-Sensitive Stocks**: Stocks with strong price fluctuations, such as SOXL and NVDA, are suitable for technical trading, while stocks influenced by macroeconomic events, such as XOM and SOXL, are ideal for hybrid trading.

Data Description

- **Stock Price Data**: Open, close, high, low prices with weekly and monthly aggregation.
- **Economic Event Data**: This includes interest rates (Fed), employment rate, CPI, and GDP, which follow cyclical release patterns. These release dates are known at the beginning of each year.

Methodology

This project employs two primary strategies: **Technical Analysis** and **Hybrid Trading Strategy**. Instead of fixed signals, each function returns a probability score in $[0, 1]$, which is optimized dynamically. The final trading signal f is determined based on the probability outputs and follows a discrete decision rule where:(-1: Sell, 0: Hold, +1: Buy)

Probability-Based Technical Trading Strategy

We apply probability functions to estimate the likelihood of bullish or bearish market conditions.

$$P_{MA} = \sigma(\lambda_{MA}(Short_{MA} - Long_{MA})) \tag{1}$$

$$P_{Risk} = \sigma(\lambda_{Risk}(VaR - ATR) + Outlier_{score}) \tag{2}$$

where $\sigma(x) = \frac{1}{1+e^{-x}}$ is the sigmoid function, and $\lambda_{MA}, \lambda_{Risk}$ are adaptive scaling parameters optimized across multiple timeframes.

Final Technical Signal:

$$f_{technical} = w_1 \cdot P_{MA} + w_2 \cdot P_{Risk} \tag{3}$$

Probability-Based Hybrid Trading Strategy

We incorporate macroeconomic factors into the model, allowing it to adapt based on economic conditions.

$$P_{Econ} = \sigma(\lambda_{Econ}(GDP - Interest_{Rate})) \tag{4}$$

Final Hybrid Signal:

$$f_{hybrid} = w_1 \cdot P_{MA} + w_2 \cdot P_{Risk} + w_3 \cdot P_{Econ} \tag{5}$$

$$f_{final} = \begin{cases} +1, & \text{if } f > T_{adaptive} \text{ (Buy)} \\ -1, & \text{if } f < -T_{adaptive} \text{ (Sell)} \\ 0, & \text{Otherwise (Hold)} \end{cases} \tag{6}$$

where f is the final signal score from either $f_{technical}$ or f_{hybrid}, and $T_{adaptive}$ is dynamically optimized to maximize Sharpe Ratio and Win/Loss Ratio.

Backtesting & Adaptive Threshold Optimization

All probability outputs are compared to an adaptive threshold $T_{adaptive}$ which is dynamically optimized using Sharpe Ratio and Win/Loss performance.

$$T_{adaptive} = \arg\max_{T} Sharpe(T) + Win/Loss(T) \tag{7}$$

Backtesting is conducted over multiple timeframes to ensure robust optimization:

- **Short-term (6 months - 1 year)**: Evaluates recent trends.
- **Mid-term (5 years)**: Tests performance across different market cycles.
- **Long-term (10 years)**: Ensures stability under varying economic conditions.

Optimization Methods

We optimize both probability scaling parameters (λ) and thresholds to ensure stability across different market conditions.

- **Bayesian Optimization**: Finds the most stable probability thresholds and λ values across multiple timeframes.
- **Grid Search**: Ensures robustness by systematically testing different threshold and λ ranges.
- **Timeframe-Aware Optimization**: We compare optimized λ values across different timeframes and select the most stable configuration that maximizes Sharpe Ratio and Win/Loss Ratio.

Conclusion

This strategy aims to maximize profitability by dynamically adjusting to market changes using probability-based signals. By comparing the performance of technical signal trading and the hybrid strategy, we can identify the most effective trading methodology.