ML-Driven Quantitative Trading: Adaptive Signal Optimization for Technical & Hybrid Strategies (Proposal)

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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 implement this strategy using Python and R, leveraging robust libraries for data analysis and quantitative modeling.

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**. Signals are categorized as -1 (Sell), 0 (Hold), and +1 (Buy).

Technical Trading Strategy

We incorporate both MA and Risk indicators. MA captures trend direction, while Risk metrics ensure controlled volatility. This ensures a robust trading execution strategy.

$$F_{MA}(short_{ma}, middle_{ma}, long_{ma}, t_{ma}) = \begin{cases} +1, & \text{Short MA} - \text{Long MA} > t_{ma} \ (Golden\ Cross) \\ -1, & \text{Short MA} - \text{Long MA} < t_{ma} \ (Death\ Cross) \\ 0, & \text{Otherwise} \end{cases} \tag{1}$$

$$F_{Risk}(ATR_{window}, VaR_{window}, MDD, Outlier_{threshold}) = \begin{cases} +1, & \text{ATR} < t_{risk} \ (Stable\ Volatility) \\ -1, & \text{VaR} > t_{risk} \ (High\ Risk) \\ -1, & \text{Extreme Outlier} > Outlier_{threshold} \\ 0, & \text{Otherwise} \end{cases} \tag{2}$$

Final Technical Signal:

$$f_{technical}(F_{MA}, F_{Risk}, technical_{threshold}) = w_1 \cdot F_{MA} + w_2 \cdot F_{Risk} \in \{-1, 0, +1\} \tag{3}$$

Hybrid Trading Strategy

This strategy enhances technical signals by incorporating macroeconomic event-driven volatility.

$$F_{Econ}(interest_{rate}, emp_{rate}, CPI, GDP, t_{econ}) = \begin{cases} +1, & \text{GDP} > t_{econ} \ (Economic\ Expansion\ Expected) \\ -1, & \text{Interest Rate} > t_{econ} \ (Interest\ Rate\ Pressure) \\ 0, & \text{Otherwise} \end{cases} \tag{4}$$

Final Hybrid Signal:

$$f_{hybrid}(F_{MA}, F_{Risk}, F_{Econ}, hybrid_{threshold}) = w_1 \cdot F_{MA} + w_2 \cdot F_{Risk} + w_3 \cdot F_{Econ} \in \{-1, 0, +1\} \tag{5}$$

Backtesting & Optimization

All function parameters and thresholds are dynamically adjusted based on historical Sharpe Ratio and Win/Loss performance. Backtesting evaluates short-term (6 months - 1 year), mid-term (5 years), and long-term (10 years) performance to ensure strategy robustness.

1. **Optimize individual function parameters** (F_{MA}, F_{Risk}, F_{econ}) across multiple timeframes.
2. **Optimize trading signals** ($f_{technical}$ and f_{hybrid}) by adjusting weights (w_1, w_2, w_3) and adaptive thresholds.
3. **Conduct backtesting** to evaluate strategy performance across different market conditions and identify the most effective optimization period.
4. **Select optimal parameters** based on the best-performing configurations across all timeframes.

Conclusion

This strategy aims to maximize profitability by dynamically adjusting to market changes. By comparing the performance of technical signal trading and the hybrid strategy, we can identify the most effective trading methodology. Additionally, we plan to further explore optimization techniques in the future, such as Bayesian Optimization.