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

## Introduction

This project explores a hybrid quantitative trading strategy that integrates fundamental analysis, technical indicators, and economic event-based trading to optimize trade decisions. The core strategy focuses on selecting fundamentally strong stocks and generating final signals by integrating technical signals and fundamental signals. These final signals determine the optimal entry and exit points while considering multiple factors to enhance decision-making. We will use Python and R for implementation due to their robust libraries for data analysis and quantitative modeling.

## Data Selection

### Stock Selection

We select stocks based on their volatility and sensitivity to economic events(Weekly, Monthly):

- **High Volatility Stocks** (for technical trading): Stocks such as SOXL, NVDA which exhibit strong price fluctuations, allowing for better technical signal opportunities.

- **Economic Event-Sensitive Stocks** (for hybrid trading): Stocks such as XOM, SOXL which are influenced by macroeconomic events and fundamental indicators.

### Data Structure

- **Stock Price Data**: Open, close, high, low prices with weekly and monthly aggregation.

- **Economic Event Data**: Includes interest rates (Fed), employment rate, CPI, GDP, which follow cyclical release patterns.

We assume that economic event release dates are known in advance and incorporate them into trading strategies.

## Trading Signal Generation

This project employs two primary strategies: **Technical Analysis** and **Hybrid Trading Strategy**.

**Technical Trading Strategy**

We generate trading signals based on moving average (MA) and risk management techniques:

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

$$(1)$$

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

**Final Technical Signal:**

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

**Hybrid Trading Strategy**

We extend technical analysis by integrating macroeconomic event-based signals:

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

$$(4)$$

**Final Hybrid Signal:**

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

*(All the Function's parameters will be optimize)*

# Backtesting & Optimization

We conduct extensive backtesting and optimization to validate the accuracy of trading signals and maximize profitability.

**Optimization:**

Optimization will be based on Sharp Ratio, and Win/Loss Ratio.

1. **Optimize over different time frames** (6 months, 1 year, 5 years, 10 years) :individual function parameters($F_{MA}$, $F_{Risk}$, $F_{econ}$)

2. **Optimize over different time frames** (6 months, 1 year, 5 years, 10 years): $f_{technical}$ and $f_{hybrid}$ signals by adjusting weights ($w_1, w_2, w_3$) and adaptive thresholds.

3. **Backtest over different time frames** (6 months, 1 year, 5 years, 10 years) to determine the best optimization period

4. **Select optimal parameters** based on best-performing configurations across all time frames

**Optimization Methods**

- **Bayesian Optimization**
- **Grid Search**
- **Random Search**

**Backtesting**

Backtesting is conducted over different time horizons to evaluate strategy robustness:

- **Short-term (6 months - 1 year)**: Evaluates recent market trends.

- **Mid-term (5 years)**: Assesses strategy stability across market cycles.

- **Long-term (10 years)**: Validates strategy performance over multiple economic conditions.

## Conclusion

- **Technical Strategy:** Uses moving averages and risk metrics for stable trading in volatile stocks.

- **Hybrid Strategy:** Incorporates macroeconomic events for smarter trading decisions.

- **Backtesting:** Evaluates strategy across multiple timeframes.

- **Optimization:** Dynamically adjusts thresholds and signal weights for better performance.

This strategy aims to enhance profitability by dynamically adapting to market conditions and integrating technical and fundamental insights. The use of adaptive thresholding allows for improved risk management and precision in entry/exit decisions.