BANK OF AMERICA

NYSE: BAC

NYSE: PNC

Pairs Trading on Banks

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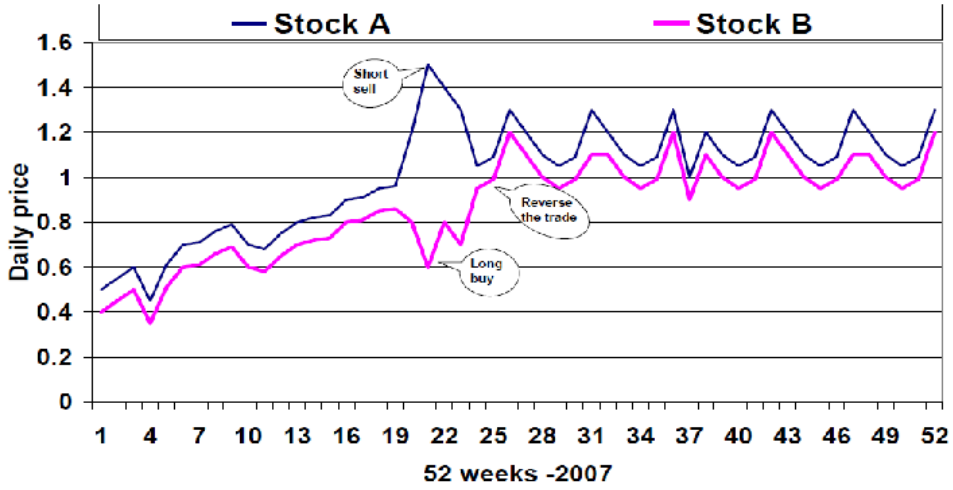
Pairs Trading

Strategy Explanation

- Market-neutral strategy: a strategy that attempts to profit from both positive and negative trends in certain markets
- Based on the historical correlation of two positively correlated securities, trades occur when the prices deviate away from the observed correlation
  - Long position on the underperforming security and short position on the overperforming security, profiting when the prices eventually converge

Restrictions

- Generally requires a correlation of over 0.8
  - However, the higher the correlation, the less prices deviate and less opportunity for returns
- More volatile securities tend to have less correlation since there are more independent drivers



Why Banks?

Stronger correlation

- Banks are often exposed to similar drivers since they hold similar assets, especially those with holdings in public markets
  - Tested theory by including banks exposed to different sets of markets
- High tendency for prices to converge after periods of volatility

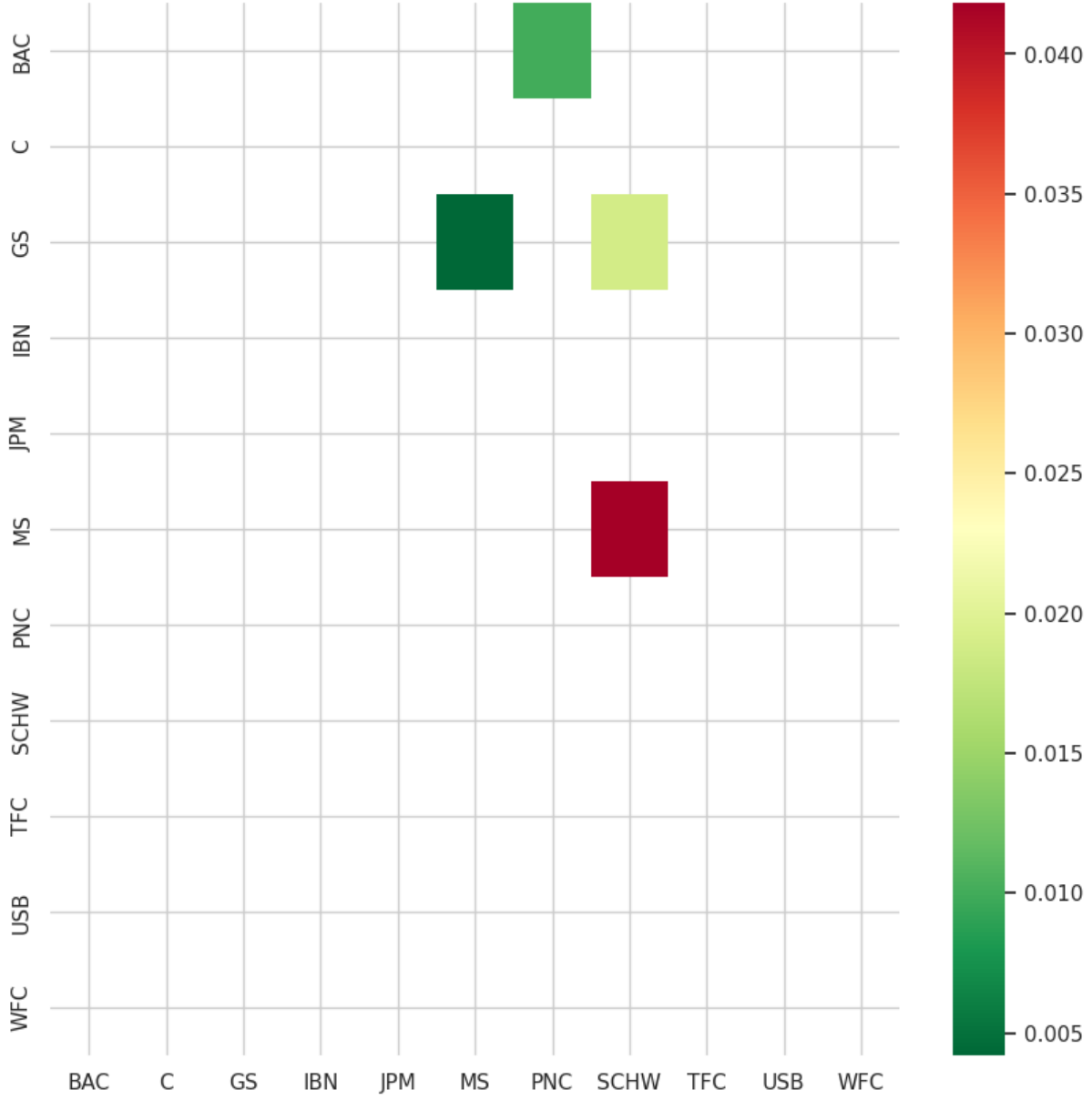
Banks Tested

- Bank of America (NYSE: BAC) $2.4T AUM
- JP Morgan Chase (NYSE: JPM) $3.3T AUM
- US Bank (NYSE: USB) $657B AUM
- Citigroup (NYSE: C) $1.6T AUM
- Wells Fargo (NYSE: WFC) $1.7T AUM
- PNC Financial (NYSE: PNC) $553B AUM
- Charles Schwab (NYSE: SCHW) $959B AUM
- Morgan Stanley (NYSE: MS) $1.4T AUM
- Goldman Sachs (NYSE: GS) $538B AUM
- Truist Financial (NYSE: TFC) $535B AUM
- ICICI Bank (NYSE: IBN) $191B AUM

Choosing the Banks

Correlation Matrix

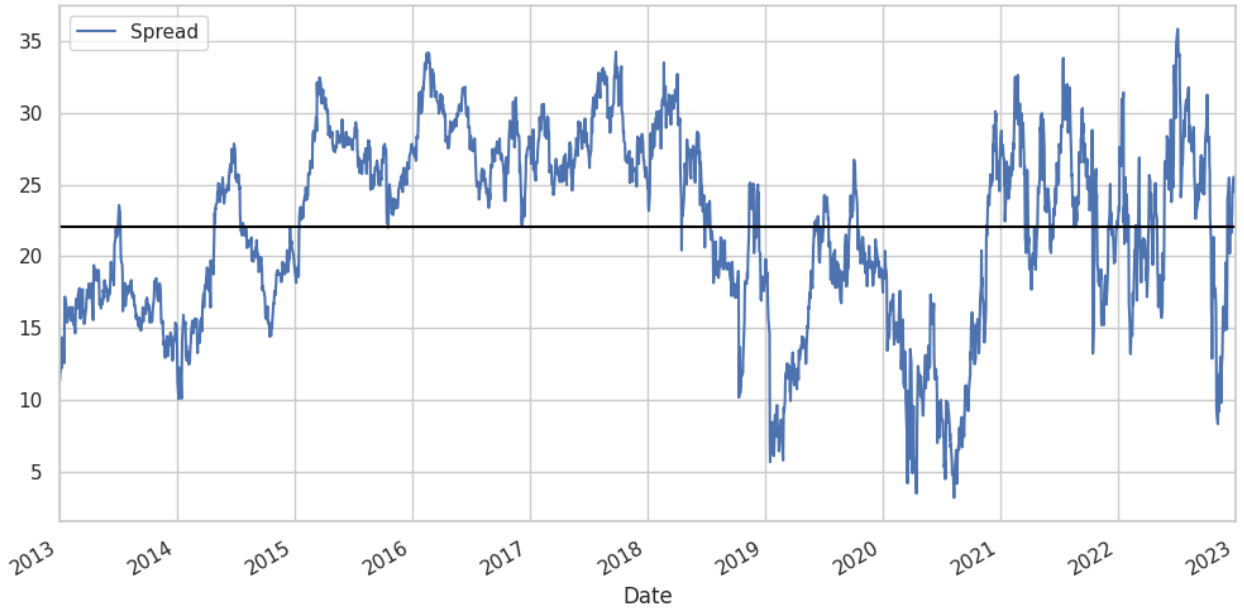
- Used coint as cointegration test to see if prices were correlated over 2013-2020 period
- Found 4 possible pairs:
  - PNC : BAC
  - MS : GS
  - SCHW : GS
  - SCHW : MS
- PNC : BAC was chosen because the pair had the largest combined AUM and similar markets
- Results confirmed first hypothesis that correlated banks operates in similar markets (ICICI Bank showed the worst correlation)

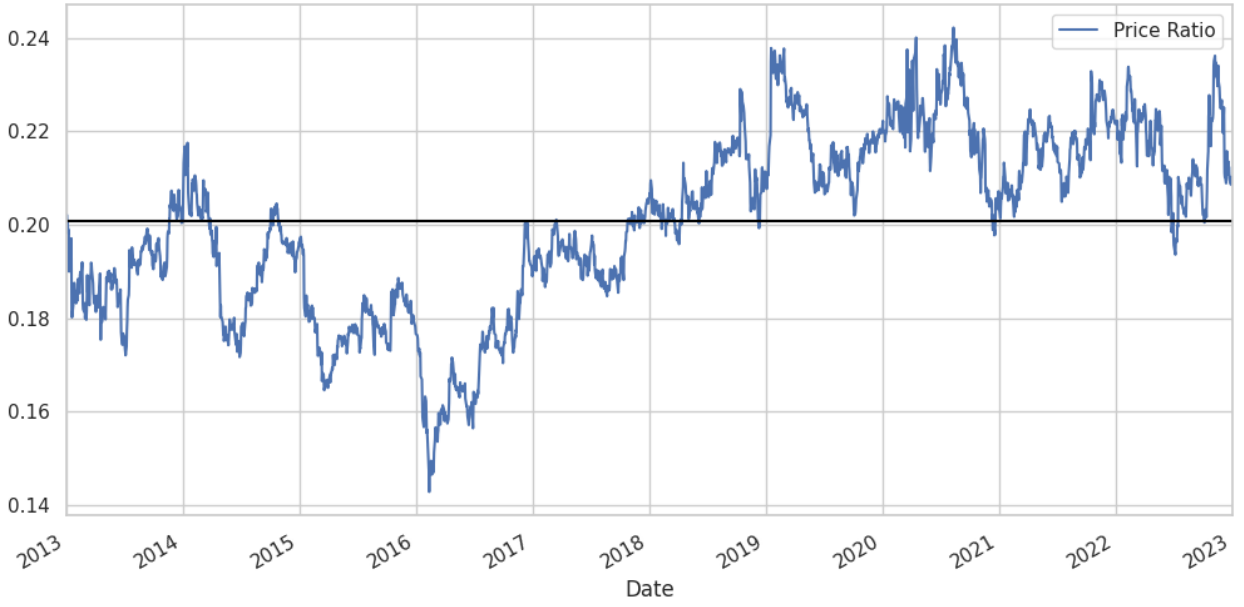


Historical Context

Historical Performance

- Graphs for the adjusted spread, price ratio, and z-score of the price ratio over the same period



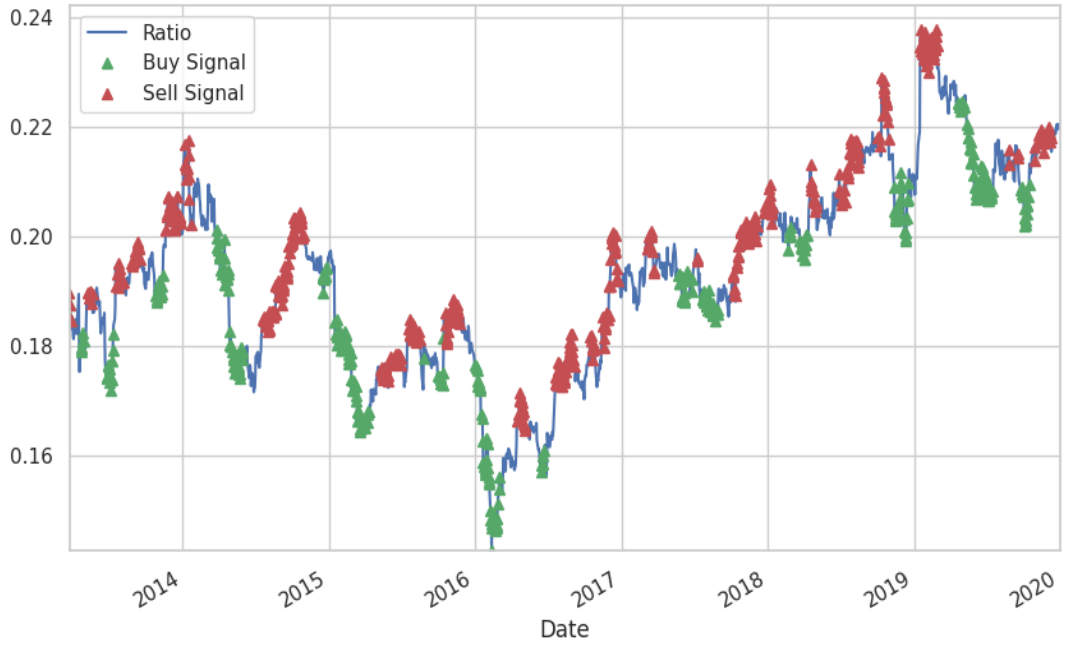


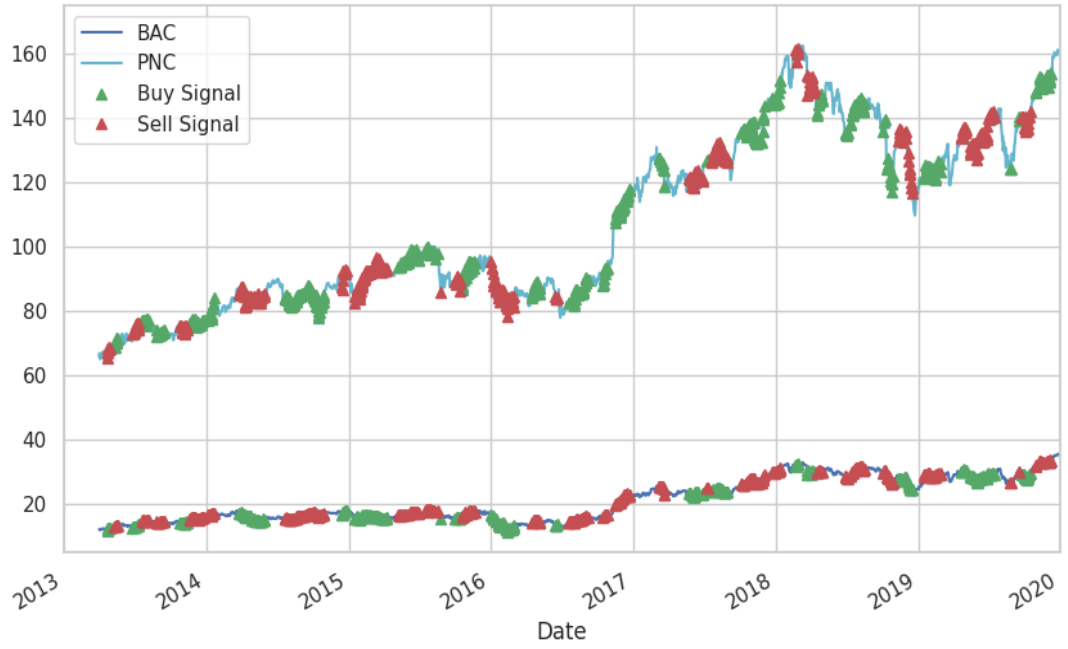
Trading Implementation

Z-score using comparative window means and 60-day SD

Trading Scheme

- Comparing an X-day moving average of the ratio of prices versus a Y-day moving average of the ratio of prices
  - Buying the ratio means buying BAC and selling PNC and selling the ration means selling BAC and buying PNC
  - Determination for X and Y was performed using an optimization function
- Graphs show the buy and sell signals relative to the ratio in the top figure and the stock prices in the bottom figure (for the training set)



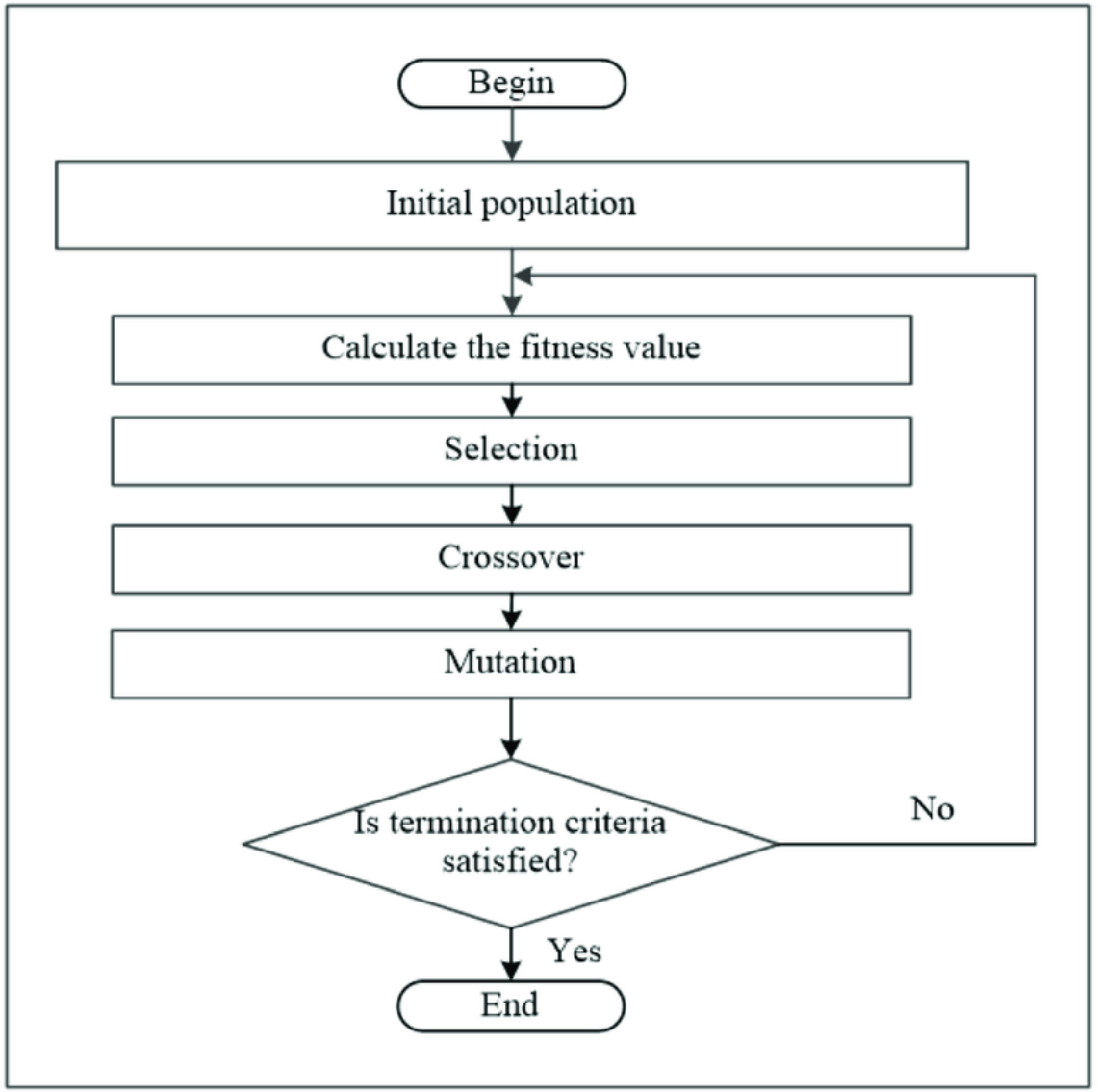


Optimization Function

Genetic Algorithm for Optimization

Genetic Algorithm

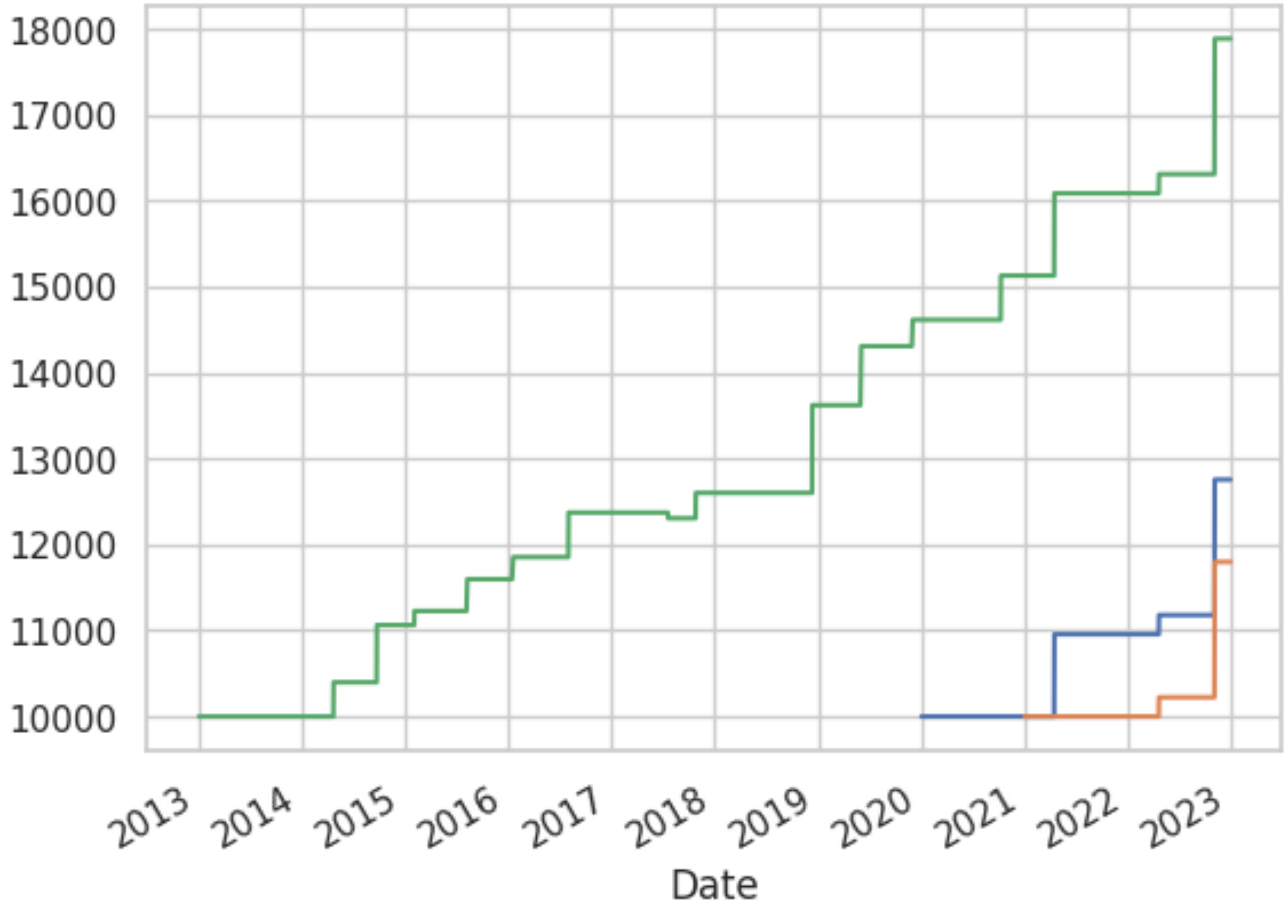
- PyGAD: Python genetic algorithm package
  - Trained on pre-2020 data
  - Emulates "natural selection": optimization algorithm improves fitness (Sharpe ratio) over generations
  - Parameters
    - Moving average windows
    - Buy/sell Z-score
    - Close position Z-score
  - Results:
    - Windows: 36-day vs. 199-day
    - Buy/sell when |z-score| > 0.75
    - Close position when |z-score| < 0.15



Returns

Various Return Statistics

- 2020-2023 (incl. COVID-19)
  - initial holdings: 10000
  - end portfolio value: 12756.89
  - total return: 2756.89
  - Sharpe: 2.0233994566596154
- 2021-2023 (not incl. COVID-19)
  - initial holdings: 10000
  - end portfolio value: 11799.68
  - total return: 1799.68
  - Sharpe: 0.976201830522665 8
- 2013-2023 (whole window)
  - initial holdings: 10000
  - end portfolio value: 17888.36
  - total return: 7888.36
  - Sharpe: 3.095029152437002



Future Considerations

Dependence on Volatility

- The algorithm tends to benefit more when stocks are more volatile and create further opportunity to capitalize on divergence from each other
- Choosing banks means that prices are highly correlated with the rest of the market
  - With similar assets in the same market, there is even less opportunity for prices to diverge

Better Optimization

- PyGAD allows for the integration of Keras and PyTorch which could help further optimize the trading algorithm
  - Better signals than just price could be utilized as the genetic algorithm can take numerous inputs to maximize a certain output (Sharpe/Returns)
- Implementing machine learning could help tackle concept drift problem common in trading algorithms

Improving Data Splits

- Because the algorithm uses sliding windows, a further step could be taken by randomizing the training windows and testing windows
  - Could help the algorithm better adapt to specific high volatility scenarios (e.g., COVID-19)
- Similarly, could utilize an LSTM or GRU to account for memory depending on randomization of testing windows

Contributions & Citations

- Matthew – Code, Signal selection, Presentation, Trading algorithm, Backtesting, Asset selection
- Jack – Code, Presentation, PyGAD optimization
- Abhishek – Presentation, Initial Planning
- Daniel – Planning, Communication with board member

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