Algorithmic Trading using 3 Strategies

Applied Masters Project

M.Sc. in Financial Markets

ACADEMIC YEAR 2024-2025

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Overview

- This project is designed to introduce you to the world of algorithmic trading by exploring different trading strategies.
- The project is divided into three main sections:
  1. Moving Average and Momentum Strategies,
  2. Value-Based Strategies, and
  3. Sentiment-Based Strategies.
- By the end of this project, you will have a deeper understanding of how algorithmic trading works
- I will not tell you exactly what to do – I expect you to figure it out
- You will have implemented and back-tested trading algorithms using historical market data.

Stock Price Dataset

- There are various ways to get price data
- One good data set for US stocks is Kaggle
- Look at the Stock Market Data (NASDAQ, NYSE, S&P500) dataset
- Date, Volume, High, Low, and Closing Price (for all NASDAQ, S&P500, and NYSE listed companies). Updated weekly.
- Link to about 9GB of data (unzipped) https://www.kaggle.com/datasets/paultimothymooney/stock-market-data
- Ends at end of 2022

Strategy 1: Moving Average and Momentum

1. Understand & implement moving average strategies
   - Simple Moving Average (SMA)
   - Write code that calculates this to different periods
2. Understand the concept of momentum
   - Relative Strength Index (RSI)
   - Write code to calculate these
3. We start with a rules-based strategy
4. We then do a ML strategy

Strategy 1a: Rules-Based Strategy - Moving Averages

Tasks:

1. Implement a strategy where a short-term moving average (e.g., S-day SMA) crosses above or below a long-term moving average (e.g., L-day SMA).
2. Write code to execute buy orders when the short-term average crosses above the long-term average and sell orders when the opposite occurs.
3. Test the algorithm on a broad range of stocks (at least 100) from the S&P index for a range of values of S and L
4. **You should report average P&L and variance of P&L for each combination of moving average periods**

Strategy 1b: Rules-Based Strategy - Momentum

Tasks:

1. Implement a strategy that buys assets when momentum indicators signal strength (e.g., RSI > 70) and sells when they signal weakness (e.g., RSI < 30).
2. Combine momentum signals with moving averages to enhance the strategy.
3. Test the algorithm on a broad range of stocks (at least 100) from the S&P index
4. **You should report average P&L and variance of P&L for each combination of moving average periods**
5. **Once again try five best combinations of RSI you can find both alone and combined with moving averages**

Strategy 1c: ML Strategy - Moving Averages

Tasks:

1. Build a Deep Learning model that takes in the stock prices and ML indicators and RSI indicators as features
2. Use a 3-layer neural network (1 hidden layers) where the inputs are the indicators and the output is a buy, sell or hold signal
3. You train it over a subset of the time series
4. You test it on another part of the timeseries
5. See if the changing number of layers or neurons per layer helps
6. Test the algorithm on a broad range of stocks (at least 100) from the S&P index
7. You should report average P&L and variance of P&L

Strategy 1b: Momentum

Tasks:

1. Implement a strategy that buys assets when momentum indicators signal strength (e.g., RSI > 70) and sells when they signal weakness (e.g., RSI < 30).
2. Combine momentum signals with moving averages to enhance the strategy.
3. **Once again try five best combinations of RSI you can find both alone and combined with moving averages**
4. **Use a machine learning algorithm with price, and various MA values and RSI as features to see if you can predict buy and sell**

Strategy 2: Value-Based

Objectives:

- Understand fundamental metrics such as P/E ratios, book value
- Backtest value-based strategies using historical data.
- Evaluate the performance of the strategies.

Strategy 2: Value-Based Strategy

Tasks:

1. Buy stocks with low P/E ratio compared to historical average
2. The Price-to-Book ratio compares a company's market value to its book value (the net asset value on the balance sheet). A low P/B ratio may indicate that the stock is undervalued relative to its assets.
3. **Use a machine learning algorithm with price, P/E and PtB values as features to see if you can predict buy and sell**

Strategy 3: Sentiment-Based Strategy

- Understand and implement sentiment-based trading strategies.
- Analyze sentiment data from news articles, social media, and other sources.
- Backtest sentiment-based strategies using historical sentiment data.
- Evaluate the performance of sentiment-based strategies.

Implement a Sentiment-Based Trading Strategy:

- Develop a strategy that buys stocks with positive sentiment and sells stocks with negative sentiment.
- Experiment with different thresholds for sentiment scores to refine the strategy.
- Combine sentiment analysis with the moving average and value-based strategies from previous sections.
- Explore how sentiment signals can enhance or detract from other strategies.
- Use historical sentiment data alongside market data to backtest the sentiment-based strategy.
- We will discuss this in more detail later in the year

Write your own Back Testing Code

- Back Testing simulates how a trading strategy would have performed in the past using historical data.
- The purpose is to evaluate the strategy's effectiveness, identify potential issues, and refine it before deploying it in live trading.
- Here are key components a back-testing code needs to handle:
  1. Load up and process price and other data
  2. Clean and prepare data
  3. Implement logic to buy and sell based on signals
  4. Define trades and measure their performance over time
  5. Incorporate realistic transaction costs
  6. Calculate metrics – return, drawdown, Sharpe ratio etc.…
  7. Visualise results

Validation and Sanity Checks

- Out-of-Sample Testing:
  - After optimizing the strategy on historical data, test it on a separate dataset (out-of-sample data) to verify its robustness.
- Sanity Checks:
  - Ensure the backtest is realistic (e.g., no future data leakage, no unrealistic execution assumptions) to prevent overestimating the strategy's performance.

Deliverables

Deliverables

- Masters Report document – see official guidance
- Send me all the code as nice Jupyter notebooks for the three trading strategies (Moving Average & Momentum, Value-Based, and Sentiment-Based) as 3 working Python Notebooks
- Prepare a presentation summarizing the project, including key findings and insights from the back-testing and analysis.

Structure of Report

- The report should be around 35 pages

- Chapter 1 - Introduction - 3 pages
- Chapter 2 - MA and Momentum Strategy – 10 pages
- Chapter 3 - Value Strategy 1 – 10 pages
- Chapter 4 - Sentiment Strategy 1 – 10 pages
- Chapter 5 - Conclusions 2 pages

- Supplementary information as a separate pdf – Code listings and more results if you wish to show them. Not part of the page count.

Evaluation Criteria

- **Report Quality**: Clear well-written report with introduction, literature review, method and with clear logic and structure.
- **Code Quality**: Clean, well-documented code with clear logic and structure.
- **Strategy Performance**: Effectiveness of the strategies based on quality of work and back-testing results.
- **Analysis and Insights**: Depth of analysis and understanding of the strategies' strengths and weaknesses.
- **Presentation**: Clarity and effectiveness in communicating the project results.

Rough Timeline (provisional)

- December - January 2025
  - Collect pricing
  - Start working on strategies
  - Write Python code to build back-testing framework
- Jan - complete moving average and momentum analysis
- Feb – Collect value data and work on value-based strategy
- March – Work on sentiment analysis
- April – Write up report