STA4020 Final Project

Fall 2024

General Instructions:

As a reminder, the Final assessment accounts for 40% of the total course grade. According to the plan made at the beginning of the semester, 30% of the final assessment is the final project, and the remaining 70% is the final exam. This document is about the final project.

The final project is due by **23:59:59 PM on Sunday, December 15, 2024**. **For late submissions, 10 points will be deducted for each 24-hour period.** For example, a delay of less than 24 hours results in a 10-point deduction, a delay of 24 to less than 48 hours results in a 20-point deduction, and so on.

Ethical and Responsible Usage of AI

While you are encouraged to explore modern tools such as AI and machine learning platforms to enhance your learning, it is essential to use these resources responsibly. All deliverables in the final project must be your original work. You may use AI to assist with understanding concepts or to guide you, but copying AI-generated answers directly without comprehension is not permitted.

Additional Reminders:

1. Independent Work: Each student must submit their own work. Direct copying from others is considered academic misconduct.

2. Formatting: Please submit your answers as a typed document (preferably in PDF format) or as clearly scanned handwritten work. Both electronic submissions and hard copies are acceptable.

3. References: If you use any external sources, including textbooks, articles, or online resources, make sure to cite them appropriately.

If you have any questions or need clarification on any part of the assignment, make sure to reach out before the due date.

Good luck!

Scenario

In this project, you will explore the practical applications of asset allocation methodologies in constructing and evaluating investment portfolios. The project aims to help you apply key concepts, including mean-variance optimization (MVO), equal-weighted portfolios (1/N), and the Black-Litterman model for incorporating views. The focus is on analyzing the performance of portfolios both in-sample and out-of-sample, under the given constraints.

IMPORTANT: For simplicity, throughout the entire project, you may assume that the risk-free rate is 0.

Tasks

Step 1: Data Collection

- Select a portfolio consisting of **at least 5 assets**. Please choose assets for which you can find recent news, headlines, and analyst reports, because you will need to provide views for these assets in the Black-Litterman model, and these news, headlines, and analyst reports will help you form views.
- Download **daily or weekly** return data for a period that covers **at least 2 years and 3 months**. The last 3 months of data will be used as out-of-sample data, while the previous data will be used as in-sample data. Please ensure that you use daily or weekly frequency (do not use lower frequencies like monthly).

Step 2: MVE Portfolio Construction

- Construct the mean-variance efficient (MVE) portfolio using the in-sample data. Please note that you are required to impose a **no-short-selling constraint** (i.e., $w_i \geq 0$ for all assets) when solving for the optimal weights. This means that you will apply numerical optimization methods to find the solutions.

  Hint: To solve for the optimal weights, you may use numerical optimization methods such as `scipy.optimize.minimize`.
- Compare the performance of your MVE portfolio with the equal-weighted portfolio (1/N) portfolio **in-sample**. Please calculate the average return, standard deviation of returns and annualized Sharpe ratio for each portfolio.

Step 3: Black-Litterman Model

- For the prior, to simplify the problem, you can use a long-window average as the prior for expected excess returns. Besides, for the covariance matrix of the expected excess return, a common choice of τ is around 0.025 to 0.05.
- Use news, analyst reports, and other publicly available information **that are available at the end of your in-sample period**. With this information, you can choose to express your views on the assets either as absolute expected excess returns or relative returns compared to others. **You can decide the number of views yourself, but please do not make it too few.**
- Use the Black-Litterman model to derive the posterior distribution of asset returns. All the necessary equations are provided in the lecture slides and have been covered extensively during lectures.
- Once you derive the posterior distribution of asset returns, construct the optimized portfolio. This involves the same optimization process as in MVE but using the updated parameters that reflect your views. **Again, please impose the no-short-selling constraint on the portfolio weights.**

Step 4: Out-of-Sample Portfolio Evaluation

For each portfolio (MVE, 1/N, and Black-Litterman), evaluate the out-of-sample performance using relevant metrics such as mean return, volatility, and Sharpe ratio.

IMPORTANT: For the out-of-sample comparison, you **must not** re-optimize the portfolio. This means that the portfolio weights, derived from the in-sample period, should be applied directly to the out-of-sample data for evaluation. In other words, you are to assume that the weights chosen during the in-sample period are fixed and not adjusted after that. Re-optimization of the portfolio weights after the in-sample period would invalidate the out-of-sample performance analysis.

Important Note

Regardless of whether you are working with in-sample or out-of-sample evaluation, assume that you will **rebalance your portfolio at the same frequency as your return data.** This means that for each period (whether daily or weekly), you will **use the same portfolio weights** calculated from the in-sample data to compute the return of the target portfolio. Once again, the portfolio weights should not be adjusted after the in-sample period for out-of-sample evaluation.

Final Report

The final report should have 3 to 5 pages (including tables and figures), covering the following:

- A summary of your data collection process, including asset selection and data preprocessing.
- A (brief) technical summary of mean-variance optimization process and the Black-Litterman model. That is, you are expected to include necessary equations as well as explain the terms in the equations.
- A discussion of how you constructed the views for the Black-Litterman model.
- A comparison of the in-sample performance of the 1/N and MVE portfolio.
- A comparison of the out-of-sample performance of the 1/N, MVE, and Black-Litterman portfolios.
- Discussion on the advantages and limitations of each strategy, as well as insights into the differences in performance. For example, consider factors like robustness, assumptions, and real-world applicability of different methods.
- Make sure you present **quantitative results (using tables and figures)** and provide interpretations of the findings.

Python Code and Results

Submit your Python code along with your report.

Grading Criteria

1. Quantitative Analysis (50 points)

1.1 Data Collection and Preprocessing (10 points)

- **(8−10 points):** Data is properly collected and cleaned (returns for at least 5 assets over 2 years and 3 months).
- **(5−7 points):** Data collection is mostly correct, but minor issues may exist (e.g., missing data points, errors in frequency, or incorrect data range).
- **(0−4 points):** Data collection or preprocessing is incomplete or incorrect (e.g., incorrect frequency, data used for less than 2 years and 3 months).

1.2 MVE Portfolio Construction (15 points)

- **(13−15 points):** MVE portfolios are constructed correctly. The optimization process is done using numerical methods, and the no-short-selling constraint is applied correctly.
- **(8−12 points):** Portfolios are constructed with minor errors (e.g., slight mistakes in optimization steps or constraints). Some use of numerical methods might be missing or incorrect.
- **(0−7 points):** Significant errors in portfolio construction or the numerical optimization process (e.g., improper use of constraints, missing numerical optimization steps).

1.3 Black-Litterman Model (20 points)

- **(15−20 points):** The Black-Litterman model is implemented correctly, including the integration of views into the optimization process. The views are logically constructed and well-justified using news or analyst reports.
- **(9−14 points):** Black-Litterman is implemented but with some issues (e.g., poor construction of views or minor calculation errors in the model).
- **(0−8 points):** The Black-Litterman model is not implemented properly, or the views are inadequately constructed or not supported by appropriate external data (news, reports, etc.).

1.4 Performance Evaluation (5 points)

- **(5 points):** Both in-sample and out-of-sample performance are calculated correctly and the results are analyzed properly.
- **(3−4 points):** Performance metrics are calculated, but some minor errors in backtesting or performance analysis.
- **(0−2 points):** Incomplete or incorrect performance evaluation, or key metrics (mean return, volatility, Sharpe ratio) are missing.

2. Technical Report (30 points)

2.1 Explanation of Methodologies (10 points)

- **(8−10 points):** Clear explanation of the portfolio construction methodologies (MVE and Black-Litterman) with necessary technical details and equations.
- **(5−7 points):** Sufficient explanation of methodologies, but some parts may lack clarity or are overly simplified.
- **(0−4 points):** Methodologies are not well explained, or key steps and reasoning are missing.

2.2 Construction of Views for Black-Litterman (10 points)

- **(8−10 points):** Views are well-constructed and supported by credible external data (news, analyst reports, etc.), with clear explanations of why these views are chosen.
- **(5−7 points):** Views are provided, but may not be fully justified or supported by data.
- **(0−4 points):** Views are either not clearly explained or not supported by external data.

2.3 Discussion and Comparison of Portfolios (10 points)

- **(8−10 points):** In-depth analysis of all three portfolios with a strong comparison in terms of performance metrics (mean return, volatility, Sharpe ratio). Clear insights into the advantages and limitations of each strategy.
- **(5−7 points):** Good comparison of the portfolios, but with some gaps in the analysis or comparison of the strategies. Some insights may be missing or unclear.
- **(0−4 points):** Comparison lacks depth or clarity, with insufficient analysis or missing key performance metrics.

3 Writing and Presentation (20 points)

3.1 Clarity and Organization (10 points)

- **(8−10 points):** The report is well-organized, logically structured, and easy to follow. Clear headings, smooth transitions, and well-presented graphs/tables.
- **(5−7 points):** The report is organized, but some parts may lack clarity or are difficult to follow. Graphs and tables may be hard to interpret.
- **(0−4 points):** Poor organization, unclear writing, and difficult-to-follow arguments. Graphs and tables may be poorly formatted or not explained.

3.2 Use of Graphs and Tables (10 points)

- **(8−10 points):** Graphs and tables are used effectively to present results and comparisons. They are well-labeled, with appropriate axes, titles, and legends.
- **(5−7 points):** Graphs and tables are included, but some may not be well-labeled or may require additional explanations.
- **(0−4 points):** Graphs and tables are missing or not helpful in presenting the findings.