Optimal Portfolio Construction

(Utilizing Modern Portfolio Theory)

Project Group 02

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Overview

Introduction to Modern Portfolio Theory

Modern Portfolio Theory (MPT) Explained:

- It lays **foundational framework** that optimizes portfolio selection for maximum return at a given level of risk through diversification.
- **Significance in Portfolio Management**: MPT introduces the critical balance between risk and return, guiding investors in constructing portfolios that align with their risk tolerance and investment objectives.
- **The Concept of the Efficient Frontier**: Represents the set of optimal portfolios offering the highest expected return for a given level of risk, illustrating the power of diversification.

Main Objectives of the Project

- **Development of an Optimization Library**: To create a robust, flexible code library capable of constructing efficient portfolios using Modern Portfolio Theory principles. This library should accommodate varying market conditions and investor preferences, including options for allowing or disallowing short selling.
- **Efficient Frontier Construction and Analysis**: Utilizing the developed library to construct the efficient frontier for a set of 50 stocks. This involves analyzing the portfolios along the frontier to identify those with the global minimum variance and the maximum Sharpe ratio, providing insights into their risk-return profiles.
- **Comparative Analysis of Optimization Techniques**: To compare the effectiveness and outcomes of quadratic programming versus Monte Carlo simulation methods in portfolio optimization. This comparison will focus on accuracy, consistency, robustness against market fluctuations, and computational efficiency, with the aim of identifying which method yields better portfolio construction under various scenarios.

Data Collection Methodology

- **Utilization of Yahoo Finance API:**
  - To construct efficient portfolios, we have used **Yahoo Finance API**.
  - For this project, we specifically gather **historical opening prices** for a selection of **52 stocks**.
  - The time frame for data collection spans a **3-year period**.
- **Calculation of Monthly Returns:**
  - The formula used for calculating monthly returns is:

$$\textbf{Monthly Return} = \left(\frac{\text{OP at Month End} - \text{OP at Month Start}}{\text{Opening Price at Month Start}} \right) \times 100\%$$

- **Importance of Opening Prices in Volatility and Return Estimation:**
  - **Market Reaction**: They reflect the market's immediate reaction to news and events that occurred after the previous trading session's close, providing insight into market sentiment and potential trends.

Quadratic Optimisation Method

- **Risk Minimization:** Quadratic optimization focuses on minimizing portfolio risk, which is a *quadratic* objective.
- **Convex Constraints:**
  - All constraints, including weights and no short selling, are *linear*, making the problem a *convex optimization*.
- **In the Case of Allowing Short Selling:**
  - Remove the positive weights constraint, allowing for *negative* asset weights.
  - Still requires the sum of weights to equal *1* for full allocation.
- **Without Short Selling:**
  - Maintains positive weights constraint to ensure all asset allocations are *non-negative*.
  - This reflects a strategy that does not engage in *short selling*.

Monte Carlo Simulation Method

- **MonteCarloOptimization Subclass:** Designed specifically for portfolio optimization through simulation.
- **Simulation Process:** Executes *10,000 simulations* of random portfolios to approximate the efficient frontier.
- **Range of Portfolio Compositions:**
  - Enables exploration of a vast array of portfolio compositions, enhancing the decision-making process.
- **Short Selling Consideration:**
  - *With Short Selling:* Samples weights uniformly from *-1 to 1*, allowing negative weights for short positions.
  - *Without Short Selling:* Samples weights uniformly from *0 to 1*, ensuring all allocations are positive and no short selling occurs.
- **Importance of Monte Carlo Simulation:**
  - Offers a comprehensive view of potential risk-return profiles, surpassing limitations of traditional optimization methods.

Comparison of Optimization Methods

- **Comparison Criteria:** Accuracy, consistency, robustness, and computational efficiency.
- **Quadratic Programming (QP):**
  - **Accuracy:** High precision in finding the optimal portfolio along the efficient frontier.
  - **Consistency:** Delivers consistent results for given inputs, beneficial for reproducibility.
  - **Robustness:** Strong performance in a wide range of market conditions, assuming model parameters are accurate.
  - **Computational Efficiency:** Faster than Monte Carlo for smaller datasets, due to deterministic nature.
  - **Practical Application:** Ideal for scenarios requiring precise optimization and when asset behavior is well-modeled by historical data.
  - **Sharpe Ratio Achieved:** 0.25, indicating higher risk-adjusted returns compared to Monte Carlo Simulation.

Comparision of Optimisation Methods(continued)

Monte Carlo Simulation (MCS):

- **Accuracy:** Less precise due to its reliance on random sampling, but provides a broad view of potential outcomes.
- **Consistency:** Results may vary across simulations, reflecting the stochastic nature of the method.
- **Robustness***:* Offers insights into the effects of market volatility and extreme conditions not always captured by QP.
- **Computational Efficiency:** Requires more computational resources, especially for a large number of simulations.
- **Practical Application***:* Suitable for understanding the distribution of outcomes and for stress-testing portfolios under various scenarios.
- **Sharpe Ratio Achieved:** 0.573, lower than QP, indicating lower risk-adjusted returns but potentially more insights into risk.

Results and Insights

- **Key Findings:**
  - **Quadratic Programming (QP):** Achieves a portfolio with a Maximum Sharpe Ratio of *0.25*, highlighting its strength in optimizing risk-adjusted returns efficiently.
  - **Monte Carlo Simulation (MCS):** Results in a portfolio with a Maximum Sharpe Ratio of *0.573*, which, while lower, provides valuable insights into the range of possible risk-return scenarios.
- **Maximum Sharpe Ratio Portfolios:**
  - *QP Portfolio:* Focused on selecting investments that offer the best return for the least risk, leading to a highly optimized balance.
  - *MCS Portfolio:* Emphasizes a well-rounded view of potential outcomes, showcasing the importance of considering a wide array of investment possibilities.
- **Global Minimum Variance Portfolio (GMVP):**
  - **Definition:** The portfolio with the lowest level of risk possible.
  - **Characteristics:**
  - Prefers investments that are less risky, which might also mean lower potential returns.
  - Highlights the power of spreading investments across various assets to reduce overall risk.

Observation

- **Differences Between Methods:** The GMVP identified may vary, with QP focusing on precision and MCS being stochastic in nature thereby offering insights into how different combinations can minimize risk.

- **Diversification:** A core theme from both methods, showing how spreading investments can protect against volatility.

- **Sharpe Ratio Simplified:** In a nutshell it is essentially a measure of how much extra return you're getting for taking on more risk. Higher is usually better, indicating you're being more efficiently rewarded for risky investments.

- **Strategic Approach:** Investors should consider their risk tolerance and investment horizon when choosing between Quadratic Programming and Monte Carlo Simulation. QP is suited for those who prioritize efficiency and precision, while MCS is better for those who value a comprehensive exploration of potential outcomes

The End