451 Feature Engineering: Week 5 Programming Assignment 2

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October 19, 2025

1. Introduction

Portfolio optimization is a key technique in finance to allocate investments across assets such that returns are maximized for a given level of risk. In this assignment, I simulated thousands of portfolio combinations using **Monte Carlo methods**, based on three hypothetical assets with known annual returns and standard deviations.

I studied two scenarios:

1. **Short selling allowed** – where asset weights can be negative.
2. **Short selling not allowed** – all weights are constrained between 0 and 1.

This report walks through the modeling assumptions, methodology, results, and insights from the simulation.

2. Asset Setup

Defined three assets with the following characteristics:

Asset	Expected Return	Standard Deviation
A	12%	20%
B	10%	10%
C	7%	5%

These values are converted into daily returns assuming 252 trading days in a year, and a correlation matrix is created to simulate asset interactions.

3. Monte Carlo Simulation

Simulated **10,000** random portfolios using NumPy and pandas. Each portfolio is defined by a set of weights across the three assets. For each, I calculated:

- **Annualized Return**: Weighted average of the expected asset returns.
- **Annualized Risk (Std Dev)**: Computed using the variance-covariance matrix of the asset returns.

Two configurations are explored:

- **With short selling**: weights can range from -1 to 2 (sum to 1).
- **Without short selling**: weights constrained to [0, 1] and sum to 1.

4. Optimization Strategy

Identified the **optimal portfolio** under each configuration by selecting the portfolio with the **highest return for the lowest standard deviation**.

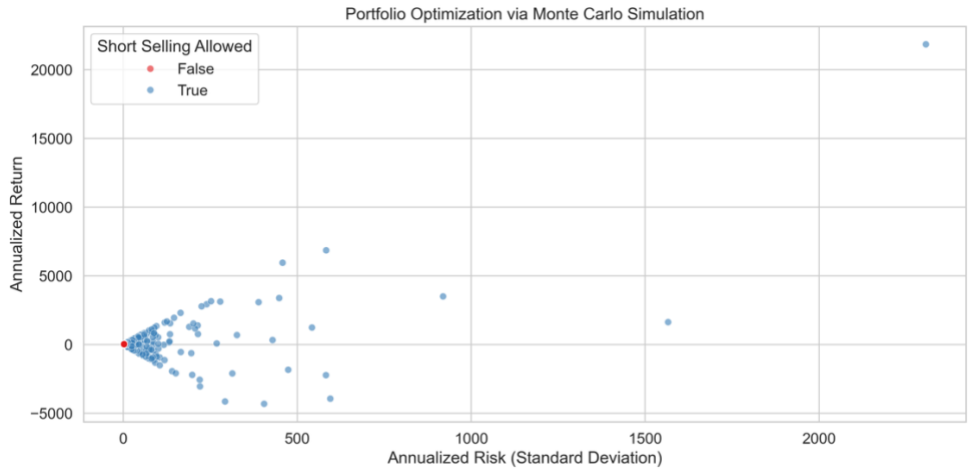
In practice:

- For short selling, this explores a wider region of the feasible frontier.
- Without short selling, the space is restricted, leading to conservative portfolios.

The simulation results are saved in monte_carlo_portfolios.csv

5. Results and Visualization

A scatter plot was created to visualize the risk-return trade-off of all portfolios:



Observations:

- The **blue dots** represent portfolios where short selling is allowed.
- The **red dot** indicates the optimal portfolio **without short selling**.
- Portfolios with short selling show greater spread and extreme values, including some with very high returns but also very high risk.

6. Insights

- **Short Selling Advantages**:
  - Provides greater flexibility in asset allocation.
  - Access to higher potential returns.
  - Broader shape of the feasible frontier.
- **Short Selling Risks**:
  - Leads to portfolios with extreme risks and negative returns.
  - More volatile, less stable allocation behavior.
- **No Short Selling**:
  - Safer and more stable allocations.
  - Portfolios are clustered in the lower left (low risk, moderate return).
  - Easier to manage and understand for conservative investors.

7. Conclusion

Monte Carlo simulation offers a powerful tool to explore portfolio combinations under uncertainty. By simulating thousands of potential portfolios, I can visualize the efficient frontier and assess the impact of constraints such as short selling.

This assignment reinforces:

- The utility of **stochastic modeling** in finance.
- The importance of **constraints** in practical portfolio design.
- The visual and statistical trade-offs between **risk and return**.