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MSDS 451: Financial Engineering

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Programming Assignment 2

Technical Report 10/19/2025

Problem Definition

This report aims to perform portfolio optimization involving four risky assets. The four assets chosen are: Coca-Cola (KO), Apple (AAPL), Amazon (AMZN), and Netflix (NFLX). Each asset has expected annual returns, associated volatilities (standard deviations), and both correlation and covariance matrices. The portfolio optimization problem involves solving for the portfolio weights given the investment constraints. The optimization problem was solved using Monte Carlo methods rather than those of standard linear programming techniques. There were two constraints given for the assignment: 1) A conservative asset allocation strategy that only employs long positions and 2) a more flexible strategy that enables the investor to use both short and long positions in their portfolio.

Data Preparation

The data used for this assignment was Yahoo! Finance historical data, similar to that which was used in assignment 1. The data was collected for each ticker of the above assets using Python's built-in "yfinance" library. The initial conditions for both the dummy dataset provided by the jumpstart R code, and the chosen asset initial conditions were alluded to earlier. For each dataset:

1. Mean returns
2. Standard deviation of returns
3. Correlation matrix
4. Covariance matrix

Monte Carlo Setup and Research Design / Programming

There were 700 random allocation sets, with each set required to satisfy a uniform distribution from -1 to 1 if short selling was allowed in the portfolio, and a uniform distribution

from 0 to 1 with weights that sum to 1 if the portfolio only included long positions. The next step was to generate multivariate normal returns for both the dummy assets A, B, C, and D, as well as the chosen assets of KO, AAPL, AMZN, and NFLX.

The multivariate normal calculations seen in the code are used to generate 700 sets of random asset returns for both datasets. Using the resulting dataframe allows us to generate our target and actual covariance and correlation matrices to compare and contrast the structures of each dataset.

Next, came generating the weights and returns we were looking for. Using the investment strategy constraints and the initial conditions mentioned earlier, we could generate expected returns, volatility, and the weights for the 700 random allocation sets.

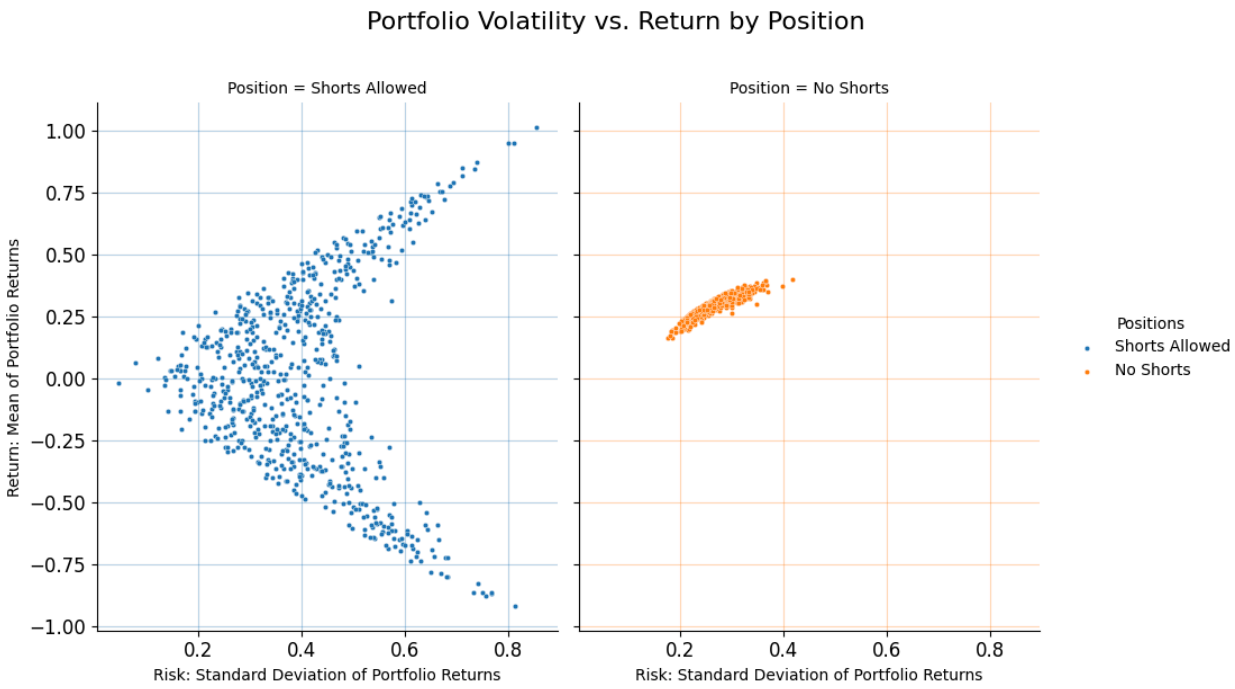
Portfolio Results DataFrame (Shorts Allowed):

	0	1	2	3	4
Return	-0.09647	-0.009623	0.030473	-0.614001	0.257793
Volatility	0.261699	0.355104	0.164251	0.579894	0.365453
Weights	[-0.7405862919882984, -0.030269982613462032, -...	[-0.27925729610356975, -0.302415537989455, -0...	[0.7874646484288095, 0.12908393903527404, -0.0...	[0.34372267055550254, -0.4945368180545935, -0....	[-0.19957363546561724, 0.40233798875951754, 0....
Position	Shorts Allowed	Shorts Allowed	Shorts Allowed	Shorts Allowed	Shorts Allowed

The figure above is an example of the returns from investment strategy #2, where both short and long positions are allowed in the portfolio. As can be expected some of the weights are negative, which indicates a short position with the associated asset. It should be noted that with both investment strategies, negative returns can be expected – meaning some weights in the portfolio are suboptimal.

Results and Conclusions

Below is the resulting scatter plot that evaluates the expected returns and associated risks for each portfolio in the Monte Carlo study. The plot is broken down in a side-by-side manner so that the viewer can easily compare long-only positions and those that include short selling as well.



There are some interesting conclusions to be drawn from these plots. In a long-only portfolio, returns and risk are much more consistent and predictable. This aligns with its reputation of being a rather conservative investment strategy. A risk-averse investor would be attracted to this type of portfolio. However, as you can see from the portfolios that include short

positions, there can be fairly high expected returns and perhaps in some cases you can assume you would “beat the market”. Unfortunately, the portfolios are much riskier. This is observed by the spread of the individual points suggesting greater standard deviations and therefore increased volatility amongst expected returns. It should also be noted that the short selling portfolios generate a higher number of negative returns, suggesting a greater number of suboptimal portfolios.