MIE1624 Assignment 3 Report
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Introduction:

This assignment aims to compare the performance of three portfolios (minimum variance, maximum return, and Sharpe ratio). Two optimization methods are used in the assignment: Markowitz mean-variance optimization and resampled Markowitz optimization with 50 repetitions. For all return level in the target return list, the efficient frontiers of these two optimization methods are computed through the monthly closing prices for 25 assets from Jan 1st, 2018, to Dec 1st, 2020 (in-sample). Then, using the frontiers, the three portfolios are computed.

At first, the minimum variance portfolio and maximum return portfolio of the in-sample data are solved with cvxpy solver. Then, the classical Markowitz efficient frontier and resampled efficient frontier are computed, and the results are stored. Next, the weights of three portfolios through two efficient frontiers are found.

Performance of 6 Portfolios:

The expected returns of the three portfolios of the two efficient frontiers on the 2021 data (out-of-sample) with a total investment of $1000 and a monthly risk-free return of 0.2% are:

Out-of-sample returns on $1000 investment:

On the Classical Efficient Frontier, the minimum variance portfolio returns $ [28.22424688]

On the Classical Efficient Frontier, the maximum return portfolio returns $ [-582.10477944]

On the Classical Efficient Frontier, the optimal Sharpe ratio portfolio returns $ [279.56668474]

On the Resampled Efficient Frontier, the minimum variance portfolio returns $ [60.19425904]

On the Resampled Efficient Frontier, the maximum return portfolio returns $ [-27.49865287]

On the Resampled Efficient Frontier, the optimal Sharpe ratio portfolio returns $ [328.21595974]

The following graph identifies the classical (MVO) and resampled efficient frontiers:

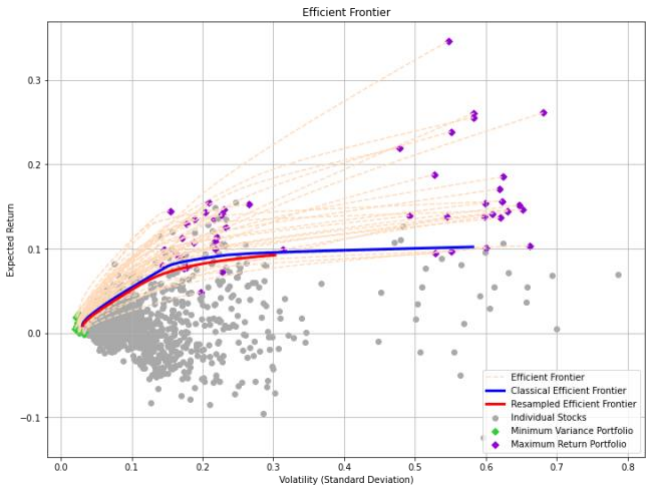

Figure 1: The classical and resampled efficient frontiers

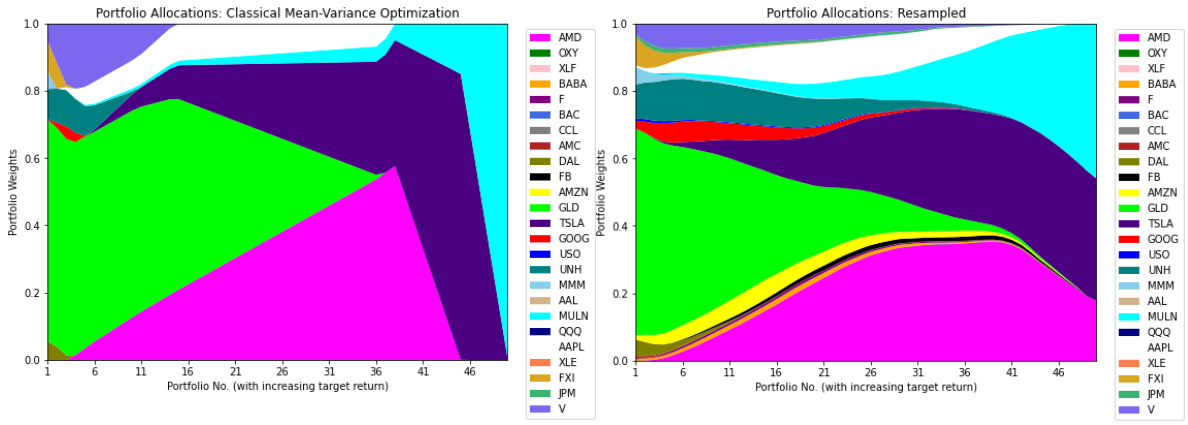

Figure 2: Portfolio compositions for classical and resampled frontiers

Discussion:

From the performance of 6 portfolios, it is obvious that for all portfolios, resampled efficient frontier generated better results than classical efficient frontier did. Among the three portfolios, minimum variance, maximum return, and Sharpe ratio, we can find that Sharpe ratio portfolio has the best performance, with optimal return $328.21595974. The optimal returns of minimum variance portfolio and maximum return portfolio are $60.19425904 and $-27.49865287, respectively. The maximum return portfolio has the lowest return.

From the Figure 1: The classical and resampled efficient frontiers, we can see that the resampled efficient frontier (red line) and the classical efficient frontier (blue line) has similar trend, while the resample efficient frontier is shorter than the classical efficient frontier. This is because at the same expected return level, the volatility of resampled optimization is smaller than the classical mean-variance optimization.

In Figure 2: Portfolio compositions for classical and resampled frontiers, compared to the portfolio composition of classical frontiers, the portfolio composition of resampled frontiers spread more evenly in the 25 assets. From the portfolio composition of classical frontiers, we can observe that the allocation of assets is centered at several assets, such as AMD, GLD, TSLA, AAPL, MULN etc. In many cases of target returns, the weights of the assets are very higher, some of them approximately equal to 1.

However, in the case of resampled frontiers, the graph shows that most assets are used in each allocation; more assets used in forming portfolio may diminish the risk of portfolio.

Therefore, from the performance of 6 portfolios and two figures, it can be concluded that resampled optimization is a better optimization method than classical Markowitz mean-variance optimization since at the same return level, the volatility is smaller which means the portfolio generated is less risky. Next, among the three kinds of portfolio, Sharpe ratio portfolio has the best performance as it has the highest optimal return value. As a result, resampled efficient frontiers should be selected, and we should invest on the Sharpe ratio portfolio.