Markowitz Portfolio Optimisation performance during COVID-19

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Summary

- One of the recent market shocks that caused turmoil on the stock market was the COVID-19 pandemic (especially the first year)
- By using blue-chip stocks data we constructed and optimized minimum variance and maximum Sharpe Ratio portfolios to test their performance in market distress
- As per our results, none of the suggested models could generate stable positive return, including equally weighted portfolio (which was used as a benchmark)
- The maximum Sharpe Ratio portfolio lead to the highest Sharpe Ratio at the cost of risk, while the minimum Variance portfolio sacrificed returns for lower volatility

Introduction

The COVID-19 pandemic caused extreme volatility in financial markets globally.

The Modern Portfolio theory, based on the Mean-Variance analysis by Markowitz offers a tool:

- To analyse risk and return in portfolios
- To construct optimal portfolios for a given level of risk

In this study, we analyze the application and performance of portfolios constructed according to Markowitz's proposal during the period of severe market turmoil caused by the COVID-19 pandemic

Research Question

What is the performance of the minimum variance portfolio (MVP) and the maximum Sharpe ratio portfolio (MSRP) of blue-chip securities compared to an equally weighted portfolio (benchmark) during the COVID-19 pandemic?

Data

Time period analysed: 1 November 2019 until 1 November 2020

Two datasets:

- Daily adjusted closing prices of the 30 constituents of the Dow Jones Industrial Average
- 10-Year US Treasury yield, which served as the risk-free rate

Rebalancing is done by-weekly with a forecasting period of one month.

Theoretical Framework

- Investors are risk-averse [2]
- With diversification, the unsystematic risk of a portfolio can be reduced if the assets are not perfectly correlated (confirmed by calculating correlation matrix) [3]
- The Efficient Frontier is comprised of all optimal portfolios that have the highest return for a given risk level [3]
- The **minimum variance portfolio (MVP)** is the optimal portfolio with the lowest possible risk (variance) for a given expected return (average daily return in October 2019) [1]
- The **maximum Sharpe ratio portfolio (MSRP)** is the optimal portfolio that has highest ratio of excess return (difference between portfolio return and risk-free rate) to risk (volatility) [1]

Constraints and assumptions

- Short selling is not allowed
- Weights sum up to 1
- Expected return is set at average daily return of given securities set in October 2019
- No transaction costs or taxes
- Portfolio returns are normally distributed
- Log returns are used for both forecasting and back-testing purposes
- Portfolio performances were measure with: return, volatility and Sharpe ratio

Implementation

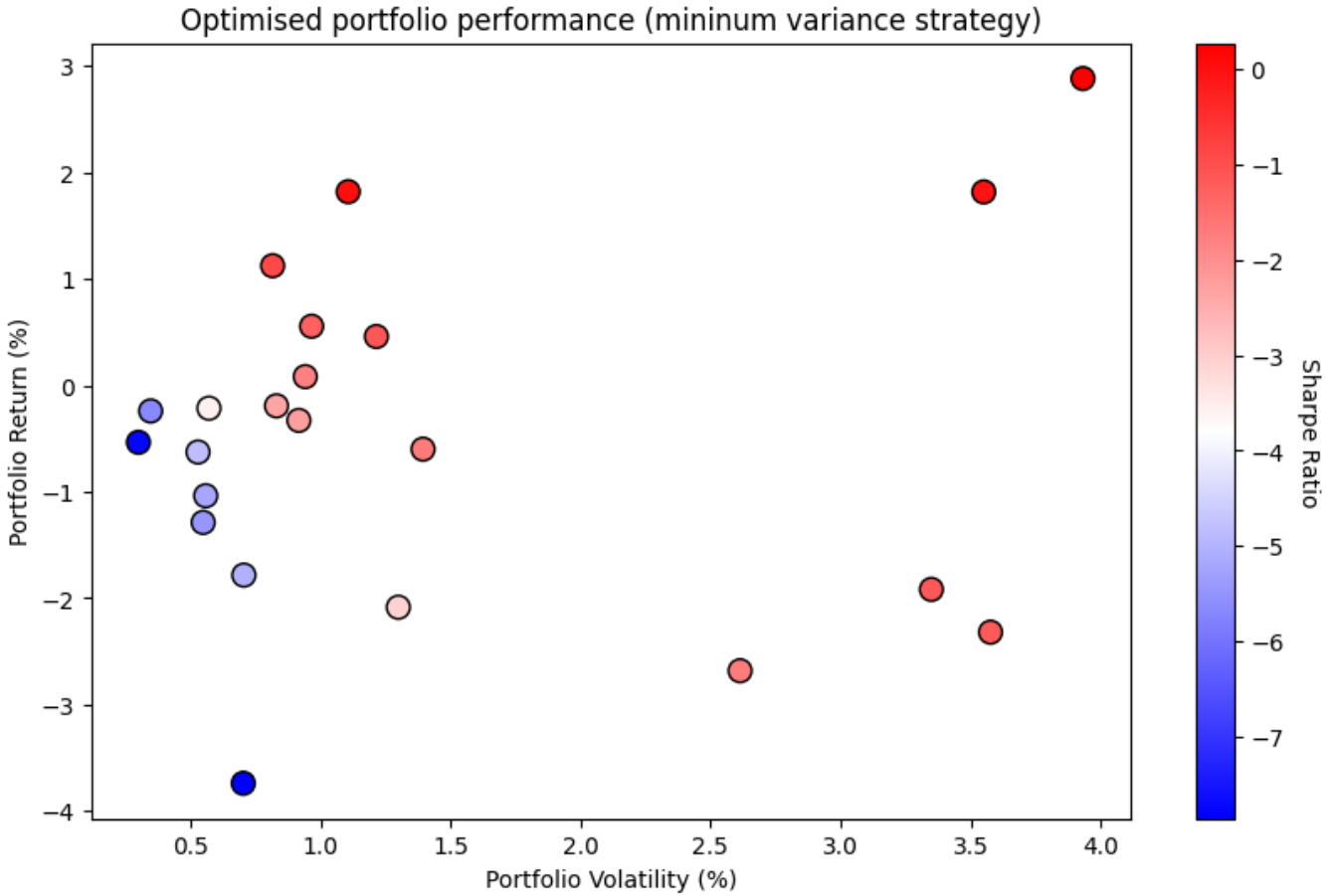
The implementation was done using Jupyter Notebook.

Based on the logarithmic returns of the DJIA constituents, the correlation matrix as well as the means, the variances, the skewnesses and the kurtoses were calculated.

We used the *cvxopt*-package (quadratic programming) to run the optimization problems with the given constrains.

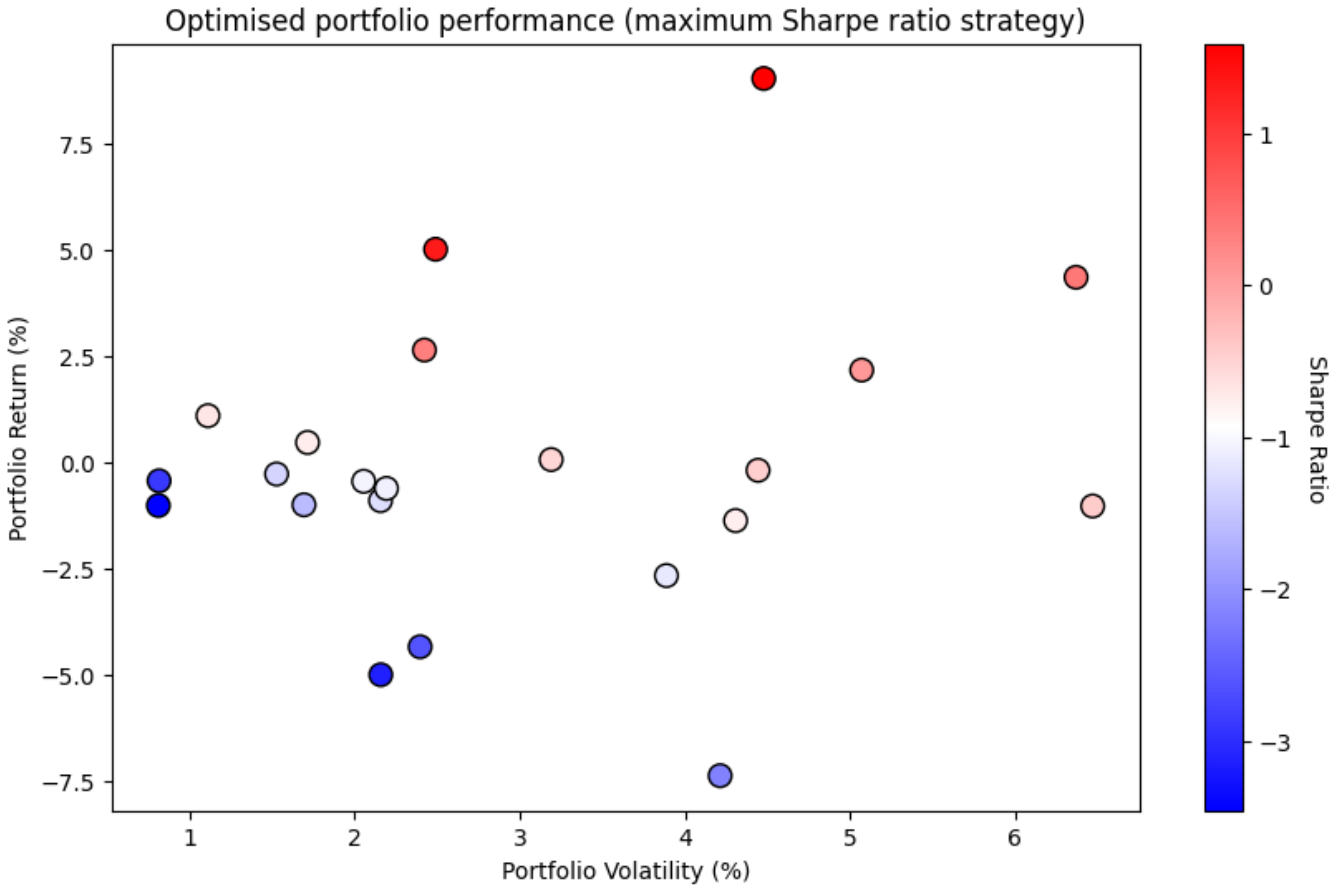
We calculated performance measures for an equally-weighted portfolio, which we used as a benchmark.

Results (Minimum Variance Portfolio, daily performance)



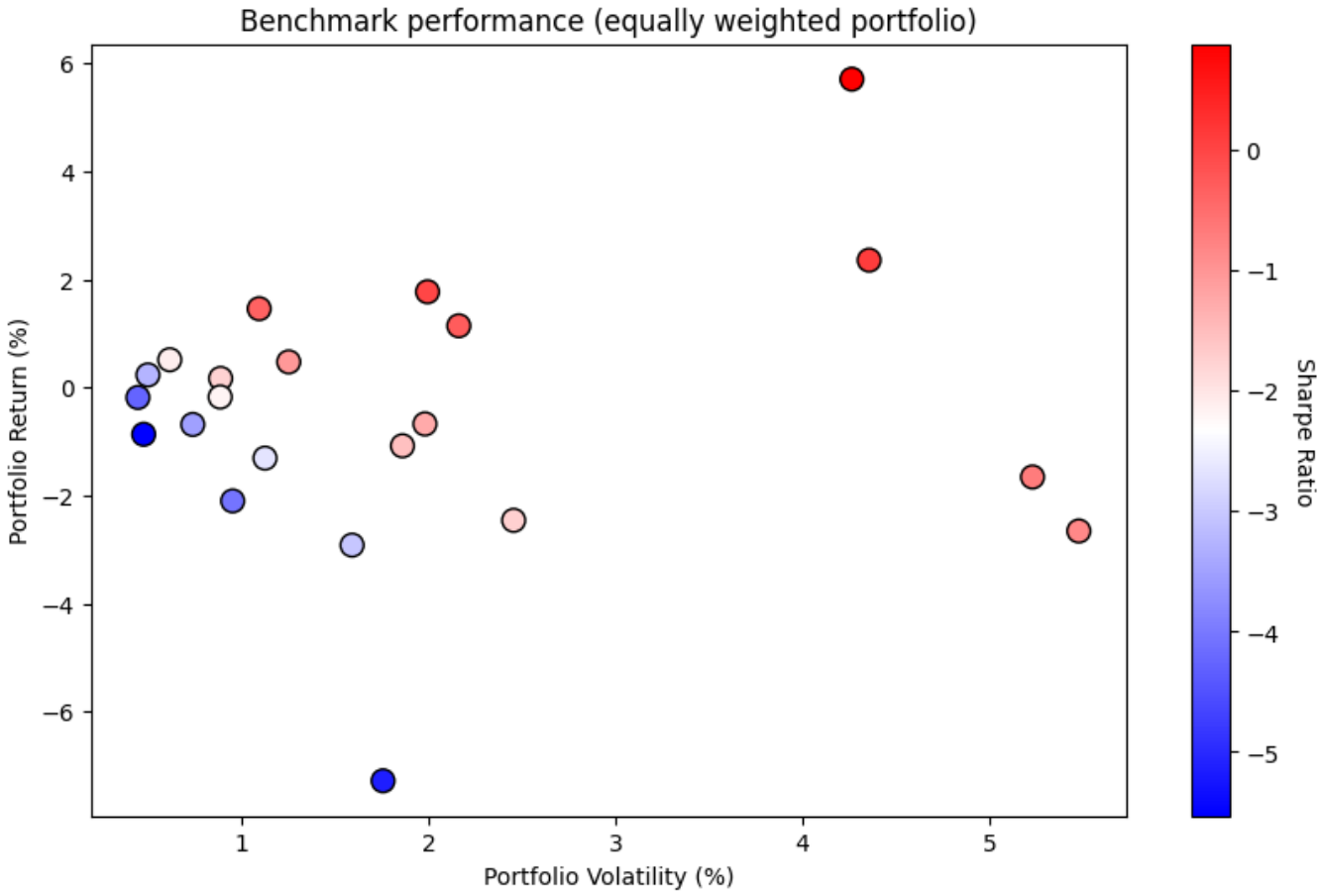
As per obtained results, we observe that in the majority of cases, the Sharpe Ratio was negative (with negative returns), with the exception for few near zero (associated with higher volatility).

Results (Maximum Sharpe Ratio Portfolio, daily performance)



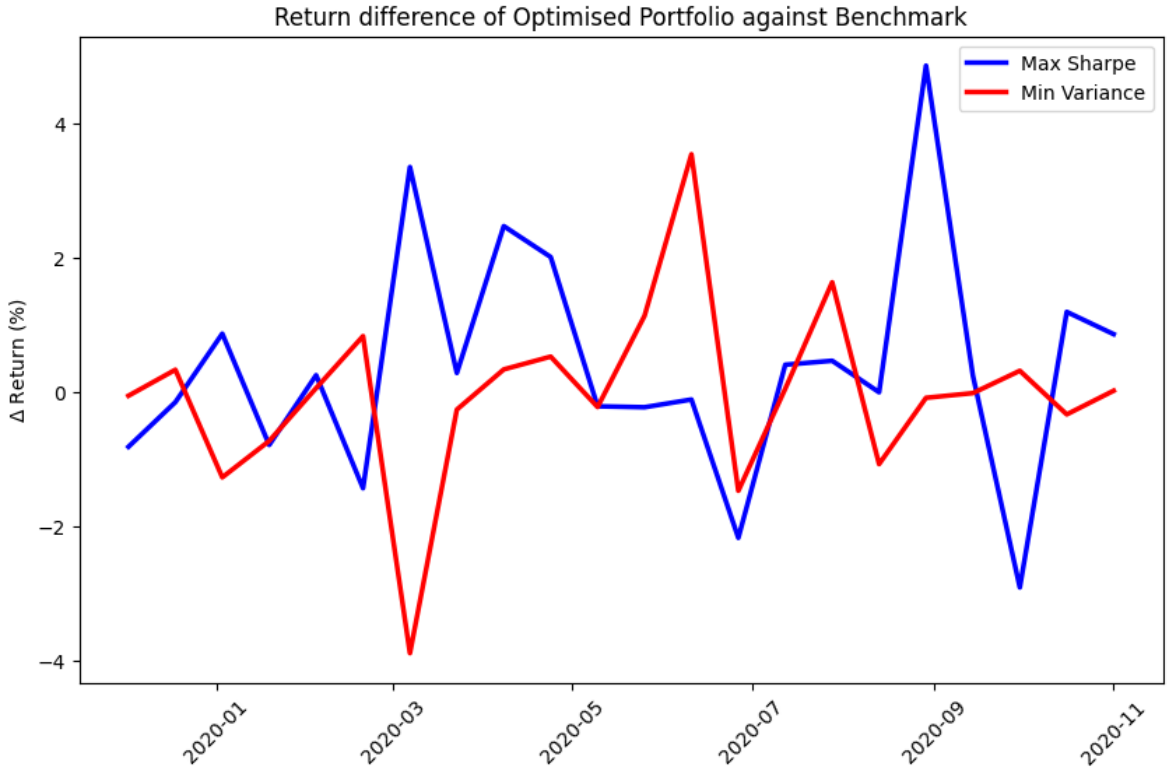
As per obtained results, we observe more cases with positive Sharpe Ratio, however associated with higher volatility and return values.

Results (Benchmark Portfolio, daily performance)



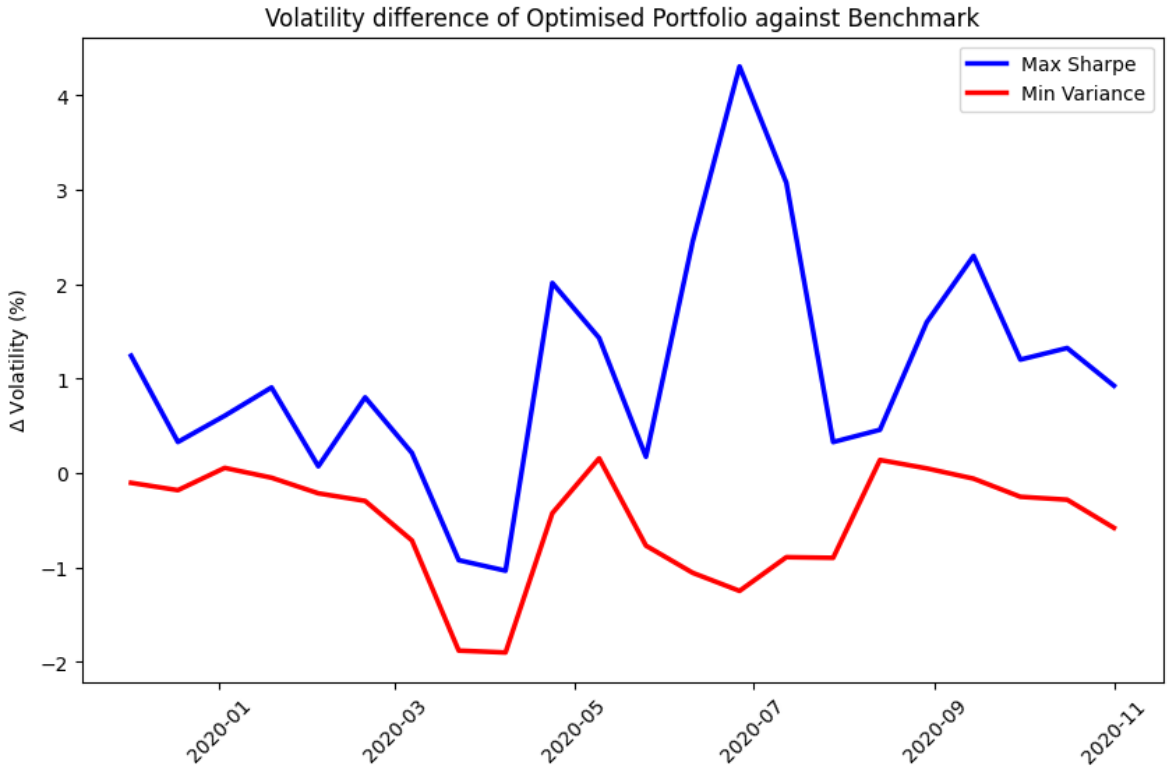
Performance of the equally weighted portfolio is more similar to MVP with few cases of positive Sharpe Ratio associated with higher volatility.

Results (Back-testing returns against benchmark, daily data)



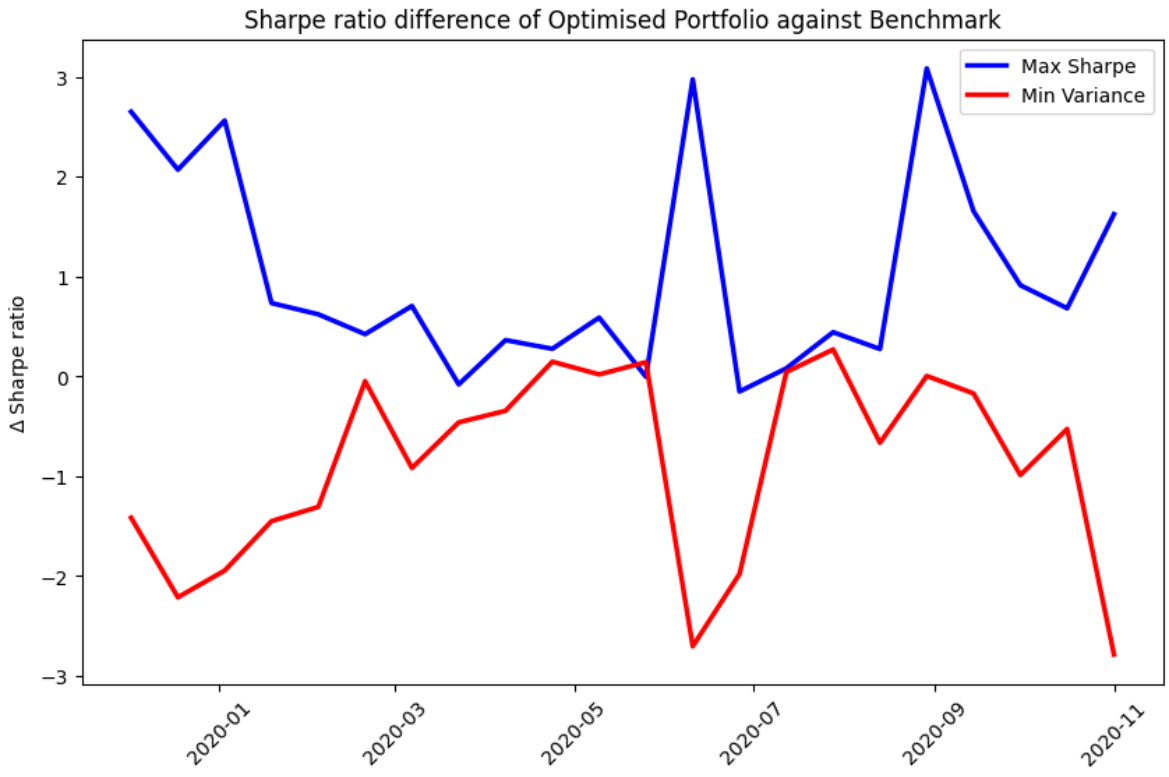
Based on the obtained results, the MSRP and MVP outperform the equally weighted portfolio only on a few instances. Interestingly, on the dates when the MSRP underperforms, the MVP delivers higher returns.

Results (Back-testing volatility against benchmark, daily data)



Similarly to previously reported results, the MSRP has the highest volatility in comparison to other models. Interestingly, the MVP has the lowest volatility on average.

Results (Back-testing Sharpe Ratio against benchmark, daily data)



As expected, the MSRP delivers the highest Sharpe Ratio. The MVP, on the other side, underperformes in comparison to the other models.

Conclusion

- In course of COVID-19 none of the models provided stable positive performance in terms of return, volatility and Sharpe ratio
- The MSRP generated more positive returns, however, at cost of higher risk (i.e. volatility)
- The MVP, at the same time, resulted in the lowest volatility among the three models, however, often generating negative return
- Overall, beating the benchmark (equally weighted portfolio) performance proved to be difficult during the market distress situation
- At the same time, it's important to assess the performance of other hedging instruments (such as commodity futures, TIPS etc.) to construct more optimal and diversified portfolio

References

[1] Olha Bodnar, Taras Bodnar, and Vilhelm Niklasson. "Constructing Bayesian tangency portfolios under short-selling restrictions". In: *Finance Research Letters* 62 (2024), p. 105065.

[2] W Brent Lindquist et al. "Advanced REIT Portfolio Optimization". In: *Springer* 10 (2022), pp. 978–3.

[3] Myles E Mangram. "A simplified perspective of the Markowitz portfolio theory". In: *Global journal of business research* 7.1 (2013), pp. 59–70.