Proceedings of the 2nd International Conference on Financial Technology and Business Analysis
DOI: 10.54254/2754-1169/56/20231100

Portfolio Optimazation Based on 10 US Stocks

Tianzhou Yu[1,a,*]

[1]*Faculty of Engineering, The Chinese University of Hong Kong, Hong Kong, China*
a. yutianzhou@link.cuhk.edu.hk
**corresponding author*

Abstract: The US stock market has recently become volatile because of the increase in interest rates, which arouses investors' focus on portfolio optimization. This study selected 10 representative US stocks from different industries listed on NASDAQ and NYSE. This paper applies Monte Carlo simulations to determine the efficient frontier and constructs portfolios with maximum Sharpe Ratio and minimum volatility. The result showed that Lululemon Athletica Inc. possesses the largest proportion of the maximum Sharpe ratio portfolio, and the Coca-Cola Company occupies the greatest weight in the min volatility portfolio. By comparing the cumulative return of the two portfolios with the NASDAQ Composite Index, the max Sharpe ratio portfolio is found to overperform the market benchmark. In the robustness test in which 8 stocks selected from the original group of assets are taken to construct a portfolio, the same result still holds. This result may demonstrate the feasibility of portfolio management for a few investors in that period.

Keywords: portfolio optimization, mean-variance analysis, US stock market

1. Introduction

The interest rate at which banks and credit unions borrow from one another is referred to as the federal funds rate, established by the Federal Reserve. It plays a crucial role as a benchmark for nearly all interest rates and its fluctuations will pose powerful impacts on global financial market. The fed funds rate is grown up to 5.25% to 5.50%, which is the highest level in the past twenty years, according to the data of the Federal Reserve [1]. The rise in the interest rate alters the long-standing low interest environment, which makes it a concerning issue for investors to mitigate the risk under the current situation through applying appropriate portfolio strategy.

Starting from portfolio selection approach proposed by Harry Markowitz, in which the mean-variance model was first introduced and conclusion that the expected return of an asset is determined by the magnitude of its own risk was also drawn, modern portfolio theory has become more comprehensive through the efforts of plenty of scholars [2]. Chen, Zhang, Mehlawat, and Jia introduced a novel method for building portfolios. This method involves integrating a machine learning-based stock prediction model and utilizing the mean-variance model for asset selection [3]. Hans, Sahamkhadam, and Stephan conducted a study on optimizing portfolio performance within the global timber and forestry industry. They compared the performance of the portfolio with the global S&P index to assess the influence of integrating social responsibility considerations into the portfolio construction process [4]. Ivanova1 and Dospatliev studied 50 stocks traded on Bulgarian Stock Exchange to find portfolio with highest return [5]. Chizari and Vazirian did research aimed at

DOI: 10.54254/2754-1169/56/20231100

identifying the most suitable stock portfolio for agricultural companies listed on the Tehran Stock Exchange [6]. Debnath and Srivastava construct their own portfolio based on stocks listed on National Stock Exchange (NSE), India [7]. Furthermore, Nisani1 and Shelef conducted research about investors' preferences for portfolio selection, showing that investors tend to pursuit risk for higher returns [8].

There is a dearth of research on investment construction in the context of interest rate hikes. Thus, this paper implements the following empirical investigations to fill the potential research gap. Firstly, the selection of stocks. Stocks from fields including technology, healthcare, finance, consumer goods, e-commerce, entertainment and telecommunications are selected from NASDAQ and NYSE. Secondly, Monte Carlo simulation is applied to simulate 10,0000 different portfolios, and the efficient frontier is obtained in which the portfolio with the highest Sharpe ratio and the portfolio with the lowest volatility are identified. Through a comparison of the cumulative returns of these two portfolios with the performance of the NASDAQ Composite Index, the optimal portfolio is determined. Additionally, robustness check is designed to examine the consistency of results. Eventually, the conclusion is drawn from previous steps.

2. Data

This paper selects 10 representative stocks from various industries listed on the NASDAQ and NYSE. The stock symbols of the 10 stocks are CSCO, EBAY, IBM, JNJ, JPM, KO, LULU, NFLX, PG, TMUS. The reason why these stocks are picked is that this mix includes technology, healthcare, finance, consumer goods, entertainment and telecommunications. This combination aims to achieve a balanced exposure to various segments of the market, potentially reducing risk through industry diversification while capturing opportunities for growth and stability. Closing prices from December 18th, 2022, to June 30th, 2023, are obtained from Yahoo Finance to conduct the study. The collected data is divided into training set, which is used for calculating the annualized return and volatility to plot the efficient frontier, and test set, which aims to evaluate the performance of portfolio by comparing the cumulative return to market benchmark return in a given period of time. The data from December 18th, 2022 to May 18th, 2022 is to find the optimal portfolio, and the data from May 30, 2022 to June 30, 2022 is to examine the performance of the portfolio. The basic statistics of the selected stocks is presented in Table 1.

Table 1: Descriptive statistics of selected assets.

	Mean	Std Dev	Min	Max
CSCO	0.0002	0.0128	-0.0462	0.0511
EBAY	0.0006	0.0186	-0.0537	0.0495
IBM	-0.0007	0.0106	-0.0459	0.0316
JNJ	-0.0009	0.0103	-0.0377	0.0439
JPM	0.0008	0.0167	-0.0557	0.0728
KO	0.0001	0.0079	-0.0308	0.0191
LULU	0.0016	0.0214	-0.0975	0.1197
NELX	0.0016	0.0231	-0.0460	0.0862
PG	0.0004	0.0092	-0.0272	0.0340
TMUS	-2.77E-06	0.0119	-0.0411	0.0318

As Table 1 presents, the highest average log return appears at NELX while the lowest standard deviation appears at KO. The paper also calculates the cumulative return for each stock in order to observe trends of these assets directly. Figure 1 reveals that NELX has maintained the highest

DOI: 10.54254/2754-1169/56/20231100

cumulative return, while JNJ has exhibited the lowest cumulative income at the end of the period of five months.

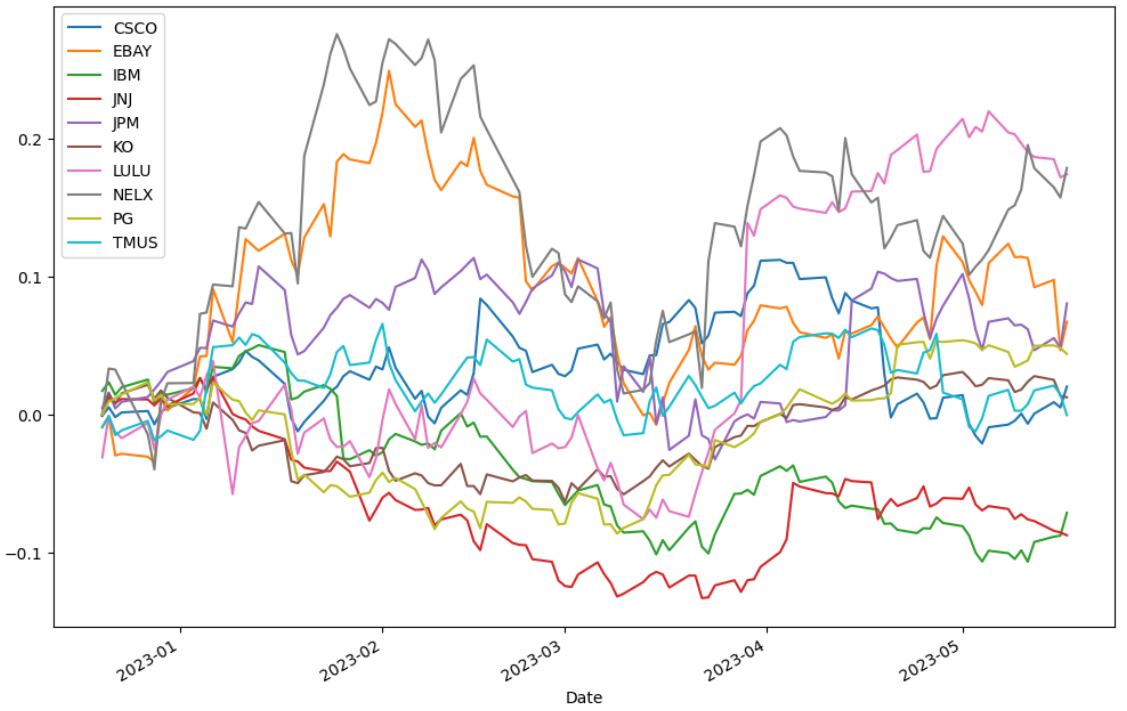

Figure 1: Cumulative returns of 10 stocks.

3. Method

3.1. Mean-Variance Analysis

Mean-variance analysis is the process of evaluating variance, which is also called risk, against expected return to achieve the optimal balance. According to Modern Portfolio Theory, investors are assumed to be rational in making investments if they can access complete information, and they seek low risk and high return while only caring about return and risk [2]. Mean-variance model enables investors to optimize the weights of their portfolio to achieve the maximum expected return at a given level of risk, or to achieve the minimum risk at a targeted return level. The equation for the expected return and variance of a portfolio are as follows:

$$E(R_P) = \sum_{i=1}^{n} w_i \, E(R_i) \tag{1}$$

Where $w_i$is the i^{th}asset weight of the portfolio, $E(R_i)$ is the expected return of the i^{th}asset.

$$\sigma_p^2 = \sum_{i}^{n} {\sigma_i}^2 \, w_i^2 + \sum_{i} \sum_{j} \sigma_i \, \sigma_j w_i w_j \rho_{ij} \tag{2}$$

Where σ_P^2 is the variance of the portfolio, $\sigma_i$is the standard deviation of the asset i^{th} return, and $\rho_{ij}$is the correlation coefficient between the returns of assets i and j.

DOI: 10.54254/2754-1169/56/20231100

Furthermore, Sharpe ratio, which is first introduced by William F. Sharpe, is a frequently used index to measure the return of an investment compared with its risk [9]. The equation is given as below.

$$\text{Sharpe Ratio} = \frac{R_P - R_f}{\sigma_p} \tag{3}$$

Where R_P is the return of a portfolio, R_f is risk-free rate and σ_p is the standard deviation of the portfolio.

3.2. Monte Carlo Simulation

The Monte Carlo simulation is a method that utilizes generated random variables and economic factors such as expected returns and volatility to simulate thousands of possible outcomes. An advantageous aspect of Monte Carlo methods is their capacity to readily facilitate scenario analysis, which means it calculates potential risk outcomes based on various assumptions [10]. In this study, it works by creating a large number of random weights, incorporating asset returns, correlations and volatility. By analyzing these simulated scenarios, investors can assess the range of possible portfolio returns and risks, make more informed decisions and construct portfolios that balance risk and return.

4. Result

100,000 simulations had been performed using the Monte Carlo method in which the data ranges from December 18th, 2022, to May 18th, 2023. The scatter plot is shown below (Figure 2), and the blue dashed line is the efficient frontier.

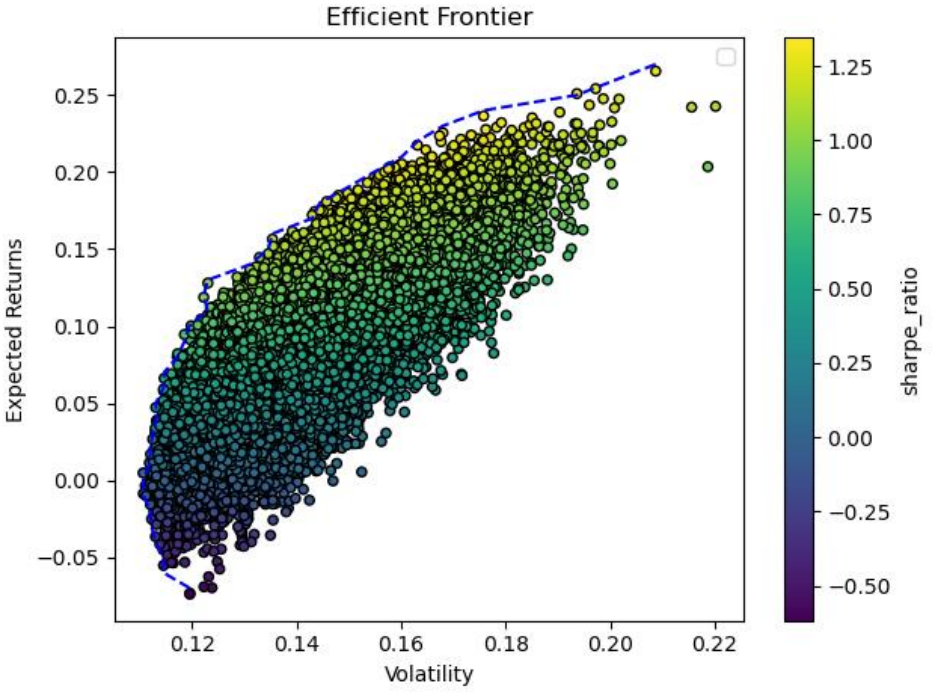

Figure 2: Efficient Frontier.

The optimal portfolios, namely max Sharpe_ratio portfolio and min volatility portfolio can be obtained from the depicted efficient frontier. As Figure 3 shows, the purple star stands for the max

DOI: 10.54254/2754-1169/56/20231100

Sharpe Ratio portfolio and the blue square represents the min volatility Portfolio. The calculated weight of each asset in two portfolios and detailed characteristics of two portfolios are in Table 2 and Table 3, respectively.

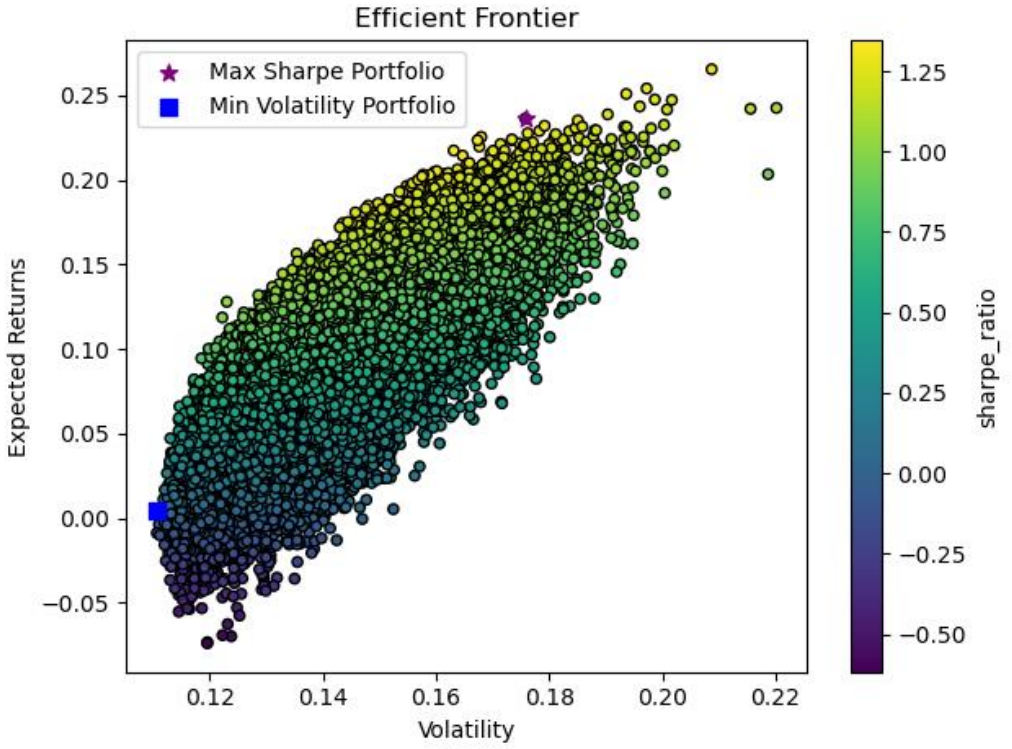

Figure 3: Max Sharpe_ratio portfolio and Min volatility portfolio.

Table 2: Weight of each asset in two portfolios (%).

Stock Code	Max Sharpe ratio	Min volatility
CSCO	3.4322	17.1787
EBAY	0.2976	0.2412
IBM	2.6921	5.5092
JNJ	2.7237	15.7817
JPM	18.6859	2.7443
KO	0.7005	22.8056
LULU	29.1786	0.8992
NFLX	17.1583	0.9034
PG	21.9663	20.5943
TMUS	3.1647	13.3425

DOI: 10.54254/2754-1169/56/20231100

Table 3: Volatility, return and Sharpe ratio of two portfolios (%).

	Return	Volatility	Sharpe Ratio
Max Sharpe Ratio portfolio	23.6421	17.5765	134.5098
Min volatility portfolio	0.4722	11.0668	4.2669

It can be seen from the tables above that the results are different apparently. In the Maximum Sharpe Ratio portfolio, LULU and PG have high weights, whose sum takes half of the total weight, while EBAY and KO have much smaller weights than those of other assets, which sums up to only 1%. In the Minimum Volatility portfolio, KO has the largest weight which is 22.81%. and the lowest weight is still EBAY which is only 0.24%. In these two portfolios, assets EBAY, IBM and PG maintain their weights relatively while other assets fluctuate a lot.

Performance of optimal portfolio obtained above can be verified after acquiring the weights of each asset in the portfolio. The paper uses the test data ranging from May 19th, 2022, to June 19th, 2022, to calculate the real risk and return using the portfolio weights and compare the result with NASDAQ Composite Index. If the cumulative return of the portfolio is greater than that of NASDAQ Composite Index, it can demonstrate that the portfolio strategies mentioned in this study are feasible.

The paper calculates the cumulative returns of max Sharpe Ratio portfolio, min Volatility portfolio and the NASDAQ Composite Index, and the results are 6.797%, 3.242% and 4.409% respectively. Figure 4 indicates that max Sharpe Ratio portfolio outperforms the market in regard to the cumulative return.

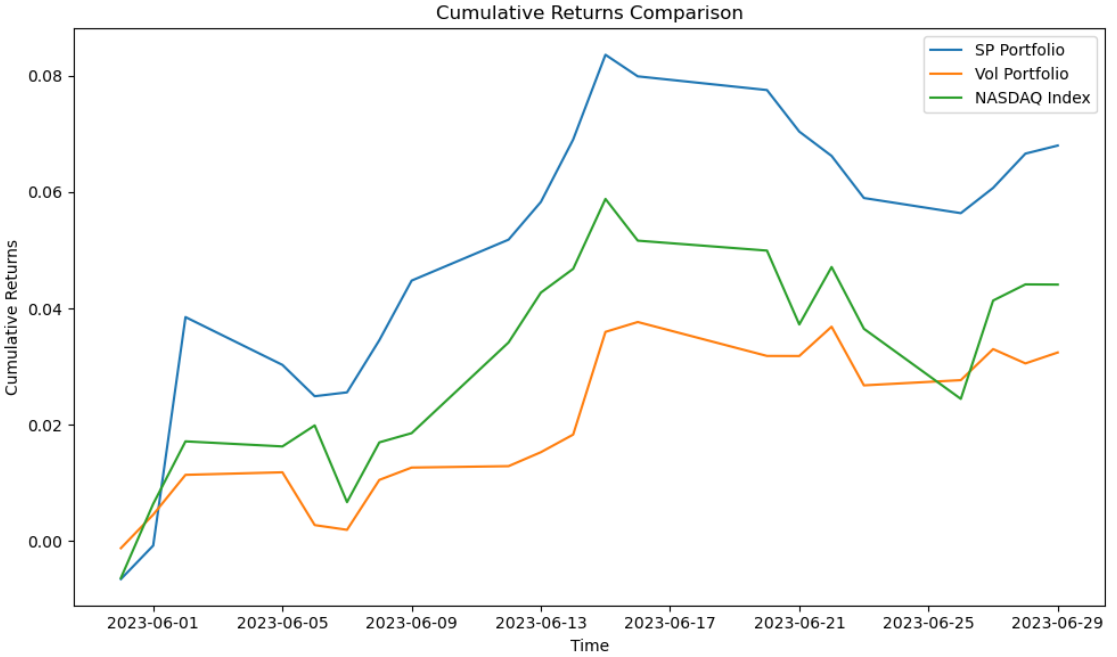

Figure 4: Comparison between NASDAQ Composite index return and the portfolio returns.

5. Robustness

A robustness test will be conducted for effectiveness. Stock EBAY and IBM are excluded from the asset group since they only account for small percentages of weights and their percentages do not fluctuate a lot in both portfolios. Then the Monte Carlo simulation is employed to generate a new set of weights. Finally, the cumulative return of new portfolios will be compared with the NASDAQ Composite Index to evaluate the performance of portfolios. The altered weights for the two optimal

DOI: 10.54254/2754-1169/56/20231100

portfolios are shown in Table 4. The cumulative returns of max Sharpe Ratio portfolio, min Volatility portfolio and the NASDAQ Composite Index are 7.269%, 3.287% and 4.409% respectively. Figure 5 indicates that max Sharpe Ratio portfolio outperforms the market in regard to the cumulative return, which presents a similar result as the 10-asset portfolio test. Therefore, validity and effectiveness of the method are verified.

Table 4: Altered weight of each asset in two portfolios (%).

Stock Code	Max Sharpe ratio	Min volatility
CSCO	0.7450	13.6851
JNJ	0.6737	19.2317
JPM	19.9857	7.0247
KO	2.6193	31.0241
LULU	28.5656	2.8318
NFLX	27.1543	0.4626
PG	18.6417	13.0318
TMUS	1.6147	12.7081

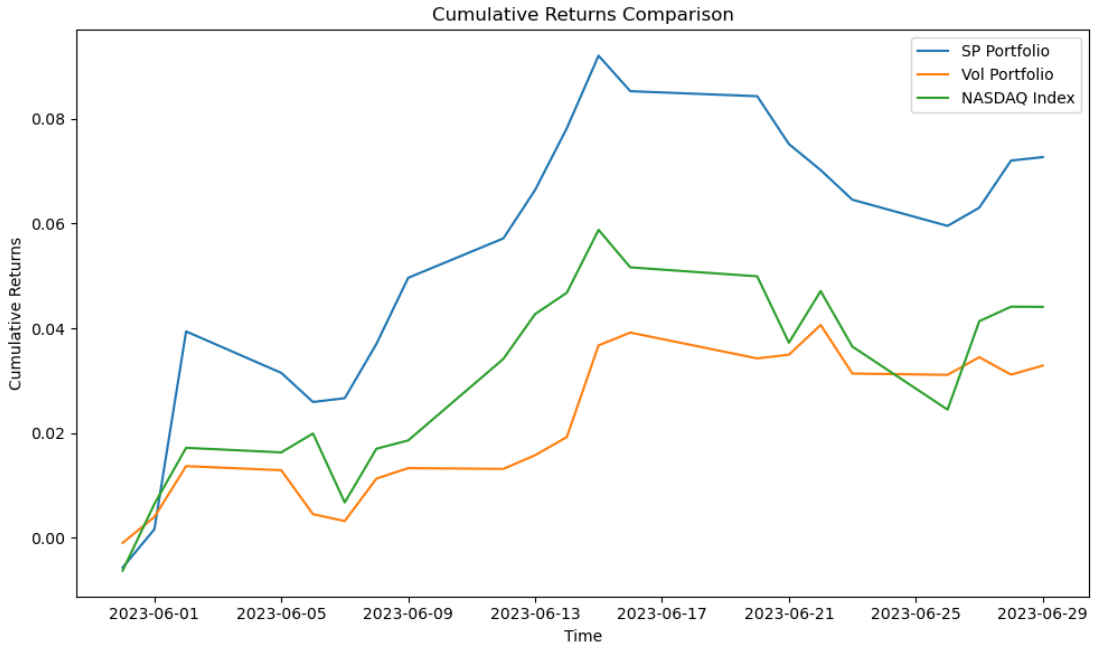

Figure 5: Comparison between NASDAQ Composite index return and altered portfolio returns.

6. Conclusion

In summary, in this study, a selection of 10 prominent US stocks spanning various industries and listed on NASDAQ and NYSE was made. By utilizing Monte Carlo simulation, the study constructed the efficient frontier and created portfolios characterized by both the highest Sharpe ratio and the lowest volatility. The findings highlighted Lululemon Athletica Inc. as the predominant component of the maximum Sharpe ratio portfolio, while the Coca-Cola Company held the largest weight in the minimum volatility portfolio. Comparing the cumulative returns of these portfolios with the NASDAQ Composite Index, the maximum Sharpe ratio portfolio exhibited superior performance as compared to the market benchmark. This result remained consistent in a robustness test, where a

DOI: 10.54254/2754-1169/56/20231100

subset of 8 stocks from the original asset group was employed for portfolio construction. For investors focusing on the US stock market during the given period, these portfolios offer valuable insights.

The asset set used in this paper is merely one representation of the U.S. stock market in a scenario of rising interest rates and does not explore other emerging U.S. equities. Subsequent researchers could incorporate emerging stocks into the portfolio to obtain a more comprehensive composition.

References

[1] *Open market operations. (2022) Retrieved from https://www.federalreserve.gov/monetarypolicy/openmarket.htm.*

[2] *Markowitz, H. (1952). Portfolio Selection. The Journal of Finance, 7(1), 77–91.*

[3] *Chen, W., Zhang, H., Mehlawat, M. K., and Jia, L. (2021). Mean–variance portfolio optimization using machine learning-based stock price prediction. Applied Soft Computing, 100, 106943.*

[4] *Lööf, H., Sahamkhadam, M., and Stephan, A. (2023). Incorporating ESG into Optimal Stock Portfolios for the Global Timber & Forestry Industry. Journal of Forest Economics, 38(2), 133–157.*

[5] *Ivanova, M., and Dospatliev, L.K. (2018). APPLICATION OF MARKOWITZ PORTFOLIO OPTIMIZATION ON BULGARIAN STOCK MARKET FROM 2013 TO 2016. International Journal of Pure and Applied Mathematics, 117.*

[6] *Chizari, A.H., and K. Vazirian. (2022). Determining the Optimal Stock Portfolio of Agricultural Companies in Tehran Stock Exchange. Journal of Agricultural Economics & Development 35(4), 383-395*

[7] *Debnath, P., and Srivastava, H. M. (2021). Optimal Returns in Indian Stock Market during Global Pandemic: A Comparative Study. Journal of Risk and Financial Management, 14(12), 592.*

[8] *Nisani, D., Shelef, A. (2021) A statistical analysis of investor preferences for portfolio selection. Empirical Economics, 61, 1883–1915.*

[9] *The sharpe ratio. (2022) Retrieved from https://web.stanford.edu/~wfsharpe/art/sr/sr.htm.*

[10] *Kroese, D. P., Brereton, T., Taimre, T., and Botev, Z. I. (2014). Why the Monte Carlo method is so important today. Wiley Interdisciplinary Reviews: Computational Statistics, 6(6), 386–392.*