

Defense Stock Portfolios in a Mean-variance Framework

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ABSTRACT

China aerospace and defense sector performed well in recent years, attracting many investors' attention. This is the first paper that conducts defense stocks portfolio design under Markowitz mean-variance framework. This paper uses the daily return during three years around the 2017 China-Indian border dispute (08/01/2016-07/31/2019) to create two target portfolios: the portfolio with the highest Sharpe ratio and the portfolio with maximum return. I examine the target portfolio's performance during the period from 08/01/2016 to 07/31/2019 and the two years around the 2020 China-Indian border dispute (08/01/2019-08/01/2021). During the 2017 China-Indian border dispute, the maximum return portfolio provides a return that is 57 times that of an equally weighted portfolio, and the highest Sharpe ratio portfolio's return is 9 times than that of the equally weighted portfolio. Target portfolios could outperform the equally weighted portfolio around the 2020 China-Indian border dispute most of the time. Still, they performed better during the three years around the 2017 China-Indian border dispute.

Keywords: *China stock market, aerospace and defense, Markowitz mean-variance framework, portfolio performance*

1. INTRODUCTION

With the processing of Afghanistan withdrawal, the Taliban regime seizes power in Afghanistan [1]. The war-related announcements often boost defense portfolios to rise [2]. This news also attracted countless investors' attention to the aerospace and defense sector. I am aware that defense stocks' rising on an annual basis is largely caused by increased military expenditure. Still, the abnormal rise in defense stocks caused by event-like international conflict is often profitable for investors [3].

China, considered as the "most important emerging power", has a huge influence on international affairs [4]. In recent years, there have been many China-related disputes: the 2016 South China Sea dispute, the 2017 and 2020 China-Indian border dispute, and some scholars point out that China and Indian's relationship will remain on this level in the long term [5-7]. The South China Sea, China-Indian border or even Taiwan Strait could be a potential trouble spot for China [8]. Therefore, it is worthwhile for investors to pay more attention to China's defense stocks for the potential profit in the future. It is also worthwhile for researchers to investigate the past performance of Chinese defense stocks.

The aerospace and defense sector of China stock market has performed well recently: the defense sector index rose from 840.24 (close index) on 10/19/2018 to 1987.96 (close index) on 8/26/2021. The defense sector index has more than doubled during the recent three years. Given all the above background, the capital market sights defense stock portfolios, seeking ways to avoid risk and maximise return.

Most existing researches on Chinese defense stocks focuses on the factors that affect defense stocks' return, especially the causality between geopolitical risks and defense companies' stocks returns, and the relationship between United States' presidency and the Chinese defense sector's index [9, 10]. Some other researches are approached from a broader perspective, focusing more on the stock market, like the relationship between China military spending and stock market development [11]. Little researches conducted portfolio selection under the traditional mean-variance framework. This paper is conducting a case study to investigate the performance of the defense stock portfolio design under the Markowitz mean-variance selection framework.

The first section of this paper delivers the reasons and purpose of this study. The second section of this paper is

about data collection, data's characteristics, data's descriptive statistics, the methodology employed in this study and confirmation of the portfolio's validation. The third part includes the empirical results, which is the defense stock portfolios' performance. The final part of this paper is the conclusion, including the conclusion I got in this study, deficiencies, and possible further study.

2. DATA AND RESEARCH METHOD

This section includes data selection, properties, summary statistics, and how I got and processed those data. The second half of this part detailly presented the methodology I employed, target portfolios and how I confirmed the validation of the target portfolios.

2.1. Data

Many major international conflicts related to China occurred after 2016, so I used 10 selected defense stocks' recent 5 years daily and monthly data, from 07/29/2016-01/08/2021, freely available from yahoo finance (<https://finance.yahoo.com/>). This period, covering the China-US trade war, 2017 and 2020 China-Indian border conflicts, could fully demonstrate how defense stocks have changed in recent years and how they acted during those important international conflicts. Stocks are selected based on their market capitalization ranking, profit margin ranking and price-to-earnings ratio ranking, provided by Eastmoney (www.eastmoney.com). Those indicators are what I believe most investors will consider when choosing stocks, and many stock websites and applications will provide the above indicators' ranking. Besides, to ensure the integrity of those data, stocks must begin trading no later than 07/29/2016 and have not been suspended for more than 1 month because of any reasons

during this period. Suspended for more than 1 month is not necessarily because the company has operating problems, and it could be because the company is involved in major asset restricting or other favorable factors. However, being suspended for a long time caused huge blank data, which could affect our final investment decision. Following the above criteria, I choose 10 defense stocks for research.

Given the daily close prices of those stocks on yahoo finance, I got their daily returns Dr by

$$Dr_{dt} = \frac{p_{dt} - p_{dt-1}}{p_{dt-1}}, \quad (1)$$

in which dt represent time in days. Then, selecting their close prices on the first day of each month, I got their monthly returns Mr similarly,

$$Mr_{mt} = \frac{p_{mt} - p_{mt-1}}{p_{mt-1}}, \quad (2)$$

in which mt represent time in months. The summary statistics of the 10 stocks' return show that almost all stocks' medians are close to 0 and there are only 2 stock's mean returns are negative, as in table 1. Next, I checked the correlation of those selected stocks, showing that all selected stocks are positively correlated. 82.2% of those 10 stocks' pairwise correlations are between 0 and 0.4, 60% pairwise correlations are less than 0.3. Although they demonstrated a certain degree of correlation, most of the correlations are not very strong, suggesting the diversification effects in a risk-return model could play a role. All the stocks' returns, no matter on a monthly basis or on a daily basis, show independence. Furthermore, I found evidence of non-normality for all the 10 selected defense stocks. Observing the histogram and their normal curve is mainly because their daily returns are too peaked in the middle, as shown in figure 1.

Table 1. Summary of some statistics-minimum, median, mean, maximum and standard deviation of selected defense stocks' daily returns. The first column refers to the stock code, and column 2-6 show their corresponding summary statistics.

Stock Code	Min	Median	Mean	Max	Standard Deviation
600031.SS	-0.0998	0.001	0.0015	0.0928	0.0227
002371.SZ	-0.1406	0.0007	0.0027	0.1003	0.0355
600893.SS	-0.1001	0	0.0007	0.1002	0.0260
000932.SZ	-0.1006	0	0.0012	0.1013	0.0273
000800.SZ	-0.1194	0	0.0004	0.1005	0.0244
000425.SZ	-0.1019	0	0.0007	0.1015	0.0215
600482.SS	-0.1001	0	-0.0003	0.0999	0.0201
600990.SS	-0.1080	0	-0.0003	0.0984	0.0237
300379.SZ	-0.1439	0	0.001	0.1628	0.0346
300352.SZ	-0.1873	0	0.0003	0.1463	0.0324

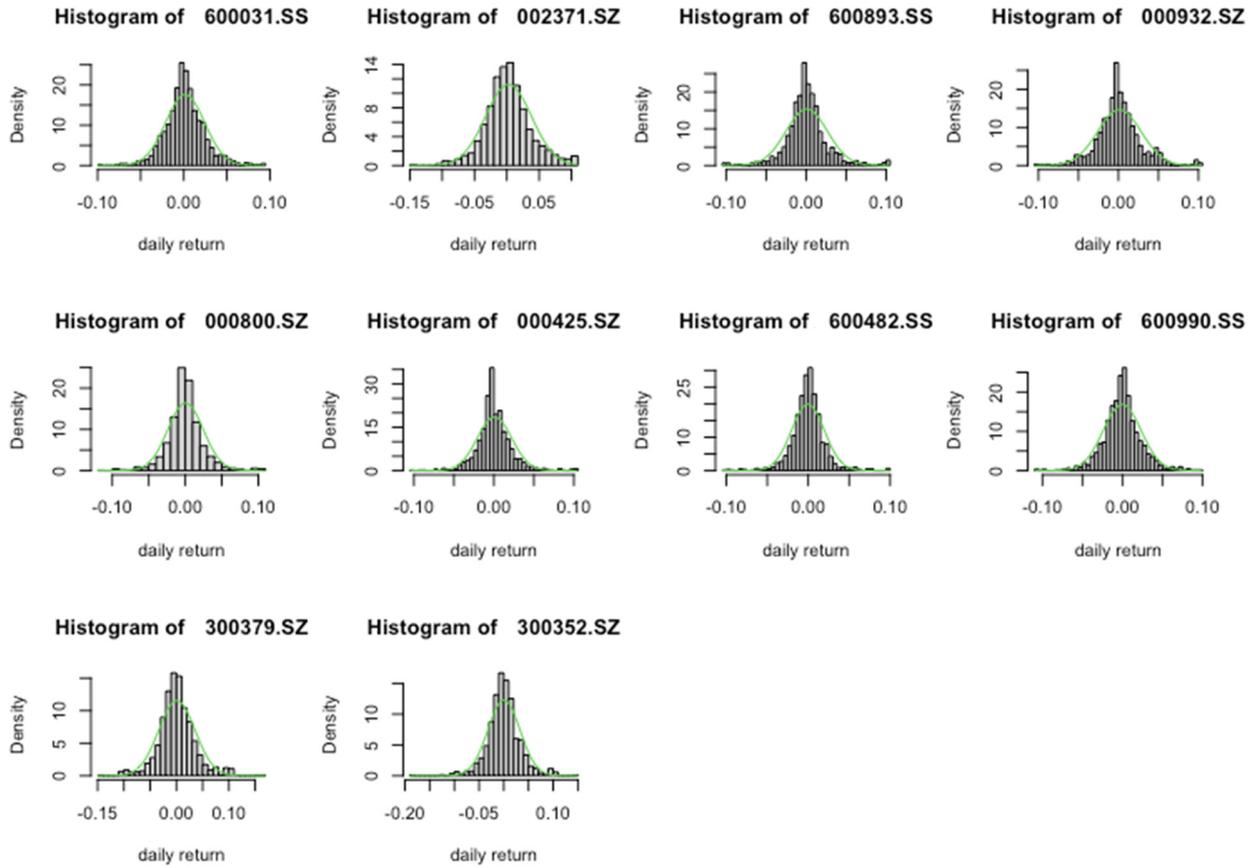


Figure 1. Histograms and normal curve of 10 selected defense stocks' daily returns. The grey bars are the histograms, showing the distribution of daily returns, and the green lines are the normal curve, showing their theoretic distribution.

2.2. Methodology

I selected portfolios that rely on the mean-variance framework, and the target portfolios are the two with the highest Sharpe ratio and maximum return. Then, I divided those stock data into two parts: portfolio selection and portfolio validation.

2.2.1. Mean-variance Framework

In the attempt to identify portfolios in defense stock investment, I employed the traditional mean-variance framework to design portfolio which introduced by Markowitz [12]. This model uses a most intuitive way to consider risk and return of assets, so it could provide a more constructive and easy-to-spread suggestion for general investors. Although there are many alternatives when the returns show non-normality, many authors like Markowitz also got desirable results when returns are not normal [13].

2.2.2. Sharpe Ratio and Maximum Return

Under the mean-variance framework, I identified two

portfolios: one with the highest Sharpe ratio and another with the maximum return [14]. The former identifies the portfolio that provides the most return per unit of risk, and the latter identifies the portfolio that provides the highest return. Those two portfolio choices could satisfy most investors' risk appetite: the more risk-averse investor could choose the highest Sharpe ratio one, and the more risk-tolerant investors could choose the maximum return one. The investors who have a risk appetite between these two could also use these two portfolios as a reference when designing their portfolios.

2.2.3. Test

Investors build their portfolios according to stocks' historical performance and hope their historical performances reveal some future insight. Therefore, it is better to check whether the portfolios we build from their historical performance still prove valid in the unknown future. Although we cannot foresee the future performance of stocks to prove the performance of our portfolios, we could use the data we have to examine portfolios' performance for unknown data. Therefore, I use the daily returns from 08/01/2016 to 07/31/2019 to build my 2 portfolios and checking those 2 portfolios'

performance by the daily returns from 08/01/2019-08/01/2021. The former period includes the 2017 China-Indian border conflict. Those data fully show how defense stocks change before, during, and after these two international conflicts, so we could expect the portfolios from this period to perform well during the later period. On the contrary, if these 2 portfolios cannot be effectively practiced in the later period, it will suggest that the portfolios I get have defects in dealing with the ever-changing international environment and financial market. Furthermore, I also check how those 2 portfolios perform on a monthly basis, using selected 10 stocks' monthly returns from 08/01/2019-08/01/2021, which covers the 2020 China-Indian border dispute, to ensure that two target portfolios work well on a monthly basis.

3. EMPIRICAL RESULTS

This section presented the empirical results of the target portfolios' weights and performance around the 2017 China-Indian border dispute (08/01/2016-7/31/2019), target portfolio's performance around the

2020 China-Indian border dispute (08/01/2019-08/01/2021). It's important to mention that target portfolios' weights are calculated from selected 10 defenses stocks' daily returns from 08/01/2016 to 07/31/2019, and two portfolios' performance from 08/01/2019 to 08/01/2021, both on a daily basis and monthly basis, are presented at the end of this section. The efficient frontier, 10 selected stocks and two target portfolios are shown in figure 2.

3.1. Defense Stocks on Mean-variance plot

On a mean-standard deviation plot, I mark all the selected stocks, highest Sharpe ratio portfolio, maximum return portfolio and equally weighted portfolio, using their daily return from 07/29/2016 to 08/01/2021. The equally weighted portfolio is added because it could show the general performance of 10 selected stocks, which will be considered later. It could be easily observed from this plot that the maximum return portfolio has the largest mean return, and the equally weighted portfolio's standard deviation is less than the 10 selected stocks'.

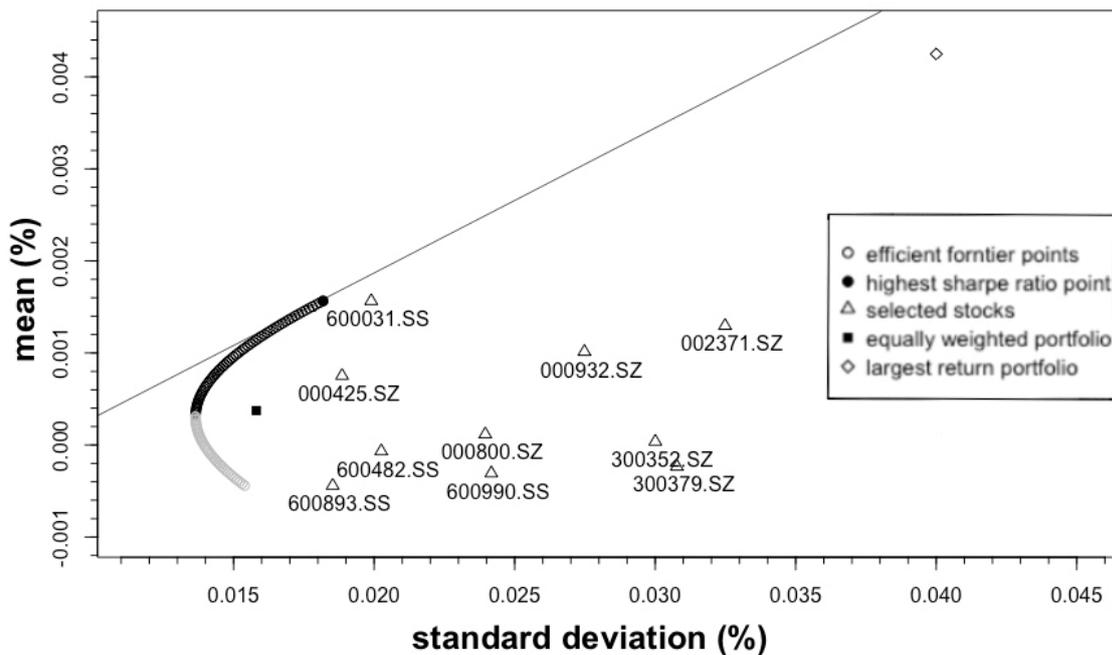


Figure 2. Selected stocks, portfolio and efficient frontier in a mean-standard deviation plot. All symbols' mean just as described in the legend. The line is the tangency line of the efficient frontier. The x-axis represents the standard deviation of return, and the y-axis represents the mean return.

3.2. Highest Sharpe Ratio Portfolio and Maximum Return Portfolio's Weights

I define the portfolio with the highest Sharpe ratio and the portfolio with maximum return as target

portfolios. Target portfolios' weights are shown in table 2. Note that target portfolios' weights are based on the selected defense stocks' daily returns from 08/01/2016 to 07/31/2019.

Table 2. Maximum return portfolio and largest Sharpe ratio portfolio's weights for each selected stock, using daily returns from 08/01/2016 to 07/31/2019. HRP represent the highest return portfolio, and LSRP represents the largest Sharpe ratio portfolio.

	600031	002371	600893	000932	000800	000425	600482	600990	300379	300352
HRP	0.6874	0.1881	-0.0852	0.143	0.0507	0.0253	0.1589	-0.0785	-0.1029	0.0132
LSRP	1.6927	0.6759	-0.8335	0.3472	-0.0982	-0.1846	-0.0163	-0.2821	-0.2830	-0.018

3.3. Return Performance during three years around 2017 China-Indian border dispute

Figure 3 shows the return performance of the maximum return portfolio, highest Sharpe ratio portfolio and the equally weighted portfolio and the blue triangle represent the 2017 China-Indian border conflict. That event stimulated these 3 portfolios to rise more dramatically. The dash line represents the maximum return portfolio. This line fluctuated violently, and the other 2 line's fluctuation is gentler. At the end of this period, the maximum return portfolio has a capital of 1233.94. The highest Sharpe ratio portfolio has a capital of around 277.43. The equally weighted portfolio has a capital of 119.8. During this period, the maximum return portfolio's return rate is 57.28 times larger than that of an equal weight portfolio, and that of the highest sharper ratio portfolio is 8.96 times that of the equally weighted portfolio. Therefore, it is proved that the 2 portfolios I created could bring a higher return than an equally weighted portfolio.

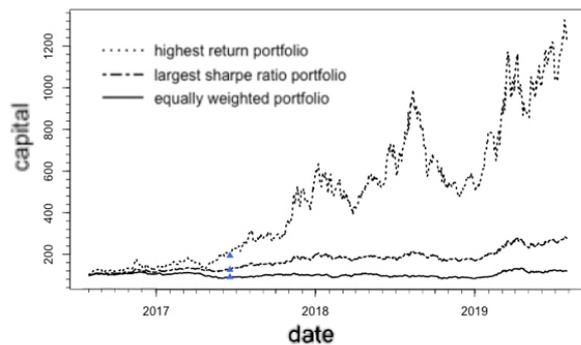


Figure 3. Assuming investors invested 100 in the maximum return portfolio, largest Sharpe ratio portfolio and equally weighted portfolio in 08/01/2016, the plot shows how these 100 capital changes over time from 08/01/2016 to 07/31/2019. Each different line's representation is as described in the legend. The small blue triangle is the 2017 China-Indian border conflict. The x-axis represents the time, and the y-axis represents the capital invested.

3.4. Return performance during two years around 2020 China-Indian border dispute

Then, I use the daily returns from 08/01/2019 to

08/01/2021 to validate the portfolio I create. Below is the return performance of the highest Sharpe ratio portfolio and equally weighted portfolio, assuming an investor invested 100 capital into both the highest Sharpe ratio portfolio and equally weighted portfolio. From April 2020, the highest Sharpe ratio portfolio' return performance is higher than that of an equally weighted portfolio. The highest Sharpe ratio portfolio's highest capital is 249.68, and that of the equally weighted portfolio is 185.78. However, at the end of this period, the highest Sharpe ratio portfolio's capital is 195.12, similar to that of an equally weighted portfolio, which is 182.00. The results are shown in figure 4.

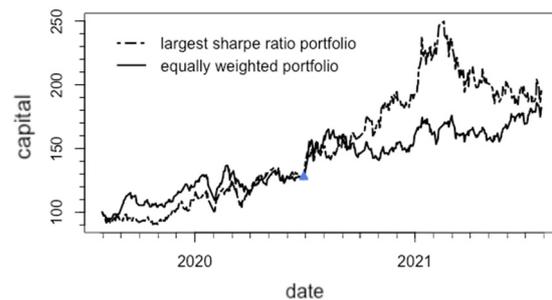


Figure 4. The return performance of the highest Sharpe ratio portfolio and equally weighted portfolio from 08/01/2019 to 08/01/2021. The x-axis represents the time, and the y-axis represents the capital invested. The blue triangle represents the 2020 China-Indian border dispute.

The maximum return portfolio's performance is similar to that of the highest sharpe ratio. Most of the time during this period, the return performance of the maximum return portfolio is higher than that of the equally weighted portfolio. The highest capital of maximum return portfolio is 440.84. At the end of this period, the maximum return portfolio's capital is 275.35, and that of the equally weighted portfolio is 182.00, which is also the highest capital. The return of the maximum return portfolio is 2.14 times than that of the equally weighted portfolio at the end of this period. Most of the time, the two portfolios I created bring a higher capital than the equally weighted portfolio. All above can be observed from figure 5. This could prove the validation of those two portfolios. They are reliable

portfolios that could provide investors with a return that is higher than the average. The only problem that needs to be mentioned is that the returns in this period (08/01/2019 -08/01/2021) are less than the return of the last period (08/01/2016 -07/31/2019).

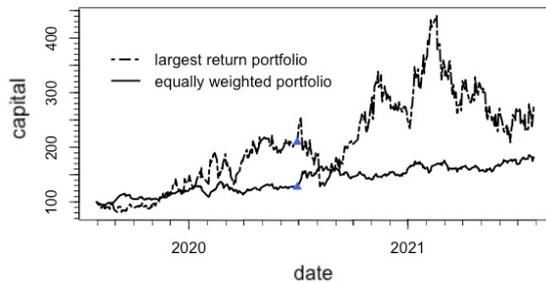


Figure 5. Return performance of maximum return ratio portfolio and equally weighted portfolio from 08/01/2019 to 08/01/2021. The x-axis represents the time, and the y-axis represents the capital invested. The blue triangle represents the 2020 China-Indian border dispute.

It can also be checked whether those 2 portfolios outperformed the equally weighted portfolio on a monthly basis. It could be observed from figure 6 that the highest return portfolio, and largest Sharpe ratio portfolio's capital is larger than that of the equally weighted portfolio in most of the time, suggesting that the portfolios I created could deal with the unknown future changes well and bring a higher return for investors.

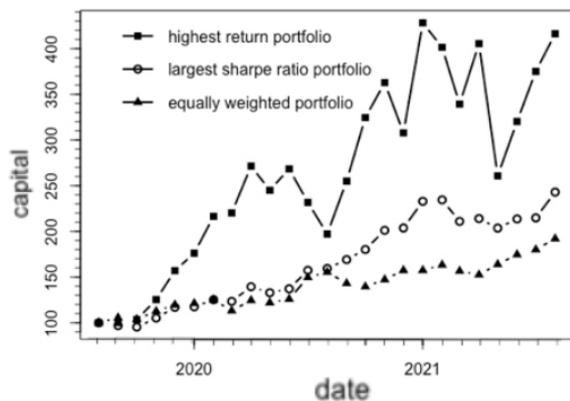


Figure 6. Return performance of maximum return portfolio, highest Sharpe ratio portfolio and equally weighted portfolio on a monthly basis from 08/01/2019 to 08/01/2021. The x-axis represents the time, and the y-axis represents the capital invested.

4. CONCLUSION

In the recent past, regional disputes occasionally reattracted investors' attention to the defense sector, and China's defense sector has a fantastic performance. In this

article, I created two defense stock portfolios - the portfolio with the highest Sharpe ratio and the maximum return – and examined their performance.

I used the daily returns during 08/01/2016 - 07/31/2019 to create a portfolio. In this period, two target portfolios performed extremely well: investing in these two portfolios could almost ensure a much higher return than the equally weighted portfolio. Then I examined two portfolio's performances during 08/01/2019 to 08/01/2021. During this period, two target portfolios could ensure a higher return in most of the time. Therefore, the defense stock portfolio created under the Markowitz mean-variance framework performed well in China stock market.

Because I created a portfolio mainly rely on the data from 2016-2019, the stocks of some outstanding defense companies, especially some technology companies listed in 2020 or 2021, have not been included in my portfolio. This will not cause the portfolio I created to put too much weight on traditional heavy industry and aerospace companies because I also include some excellent technology companies with a longer history.

I could clearly observe that although the two target portfolios' performance is better than that of the equally weighted portfolio from 08/01/2019 to 08/01/2021, they provide less return compared with the period 08/01/2016 - 07/31/2019, and their return could be sometimes less than that of the equally weighted portfolio. It could be concluded that the two target portfolios performed less well from 08/01/2019 to 08/01/2021 compared with the previous period. Therefore, future studies could create a portfolio with more recent data, adding some newly listed defense companies into the portfolio. Future studies could also combine Markowitz's mean-variance selection framework with artificial intelligence to design a portfolio based on the most updated stock data, providing portfolio design recommendations based on real-time stock data to improve return. I leave all those possible research directions to future study.

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