Proceedings of the 2023 International Conference on Management Research and Economic Development
DOI: 10.54254/2754-1169/23/20230401

Portfolio Optimization Based on 7 Chinese Stocks

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Abstract: Since 2022, China has entered the post-pandemic era, with its strategic focus shifting from fighting the epidemic to economic recovery. The A-share market is under the influence of uncertain factors such as the novel coronavirus epidemic as well as the outbreak of conflict between Russia and Ukraine. In order to avoid risks and increase returns, optimizing investment portfolio has aroused people's attention and become the focus of research. This paper takes China's stock market as the research object, selects seven industries favored by investors, and selects a representative stock in each industry for portfolio construction and analysis. This paper collects data on the closing price of seven stocks from January 4 to April 1, 2022, and then randomly generates 100,000 different investment portfolios through Monte Carlo method. The portfolios with the lowest volatility and highest Sharpe ratio are built using the mean variance model. The effectiveness of these three portfolios was evaluated with real daily returns from April 6 to May 11, 2022, after acquiring the weights of these equities, and it was compared to the performance of the CSI 300 in the same time frame. The result indicates that the minimum variance portfolio has the largest cumulative return, which exceeds the cumulative return of CSI 300 in the same period, while equally weighted and the maximum Sharpe ratio portfolios generate lower yields than the market level.

Keywords: portfolio optimization, mean-variance, portfolio management, Chinese A-shares

1. Introduction

Due to its growing market size and greater accessibility, the China A-shares market is attracting increasing emphasis from international investors [1]. A-shares had an overall market valuation of 88 trillion yuan at the time of March 10, 2023, which makes it the second-largest capital market in the world, the largest developing capital market, as well as one of the capital markets with the highest rate of growth, playing an extremely important role in the world capital market. China's growing influence in global financial markets, combined with ongoing financial reforms, make A-shares an attractive investment option for foreign investors [2]. The rapid spread of the novel coronavirus pneumonia in a short period of time across the country has had a severe impact on the stock market [3]. The difference in stock price trends between different industries is more obvious, and the risk of investing in a single stock is increasing. Thus, diversified investment portfolios have been widely studied and used. Investors may be able to get higher returns while balancing risk with a diverse portfolio, so as to reduce risks while improving returns [4-5]. Portfolio optimization is becoming a more and more interesting issue in China.

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Actually, there is still a lack of research on the portfolio of China's A-share market, and the main research direction is also focused on the research on the portfolio composed of a single industry. For example, Trinks, Scholtens and Mulder found that the divestment (fossil-free) portfolio did not perform noticeably worse than the unrestricted market portfolio over a significant period of time for various types of fossil fuel business and market indices and market indices, demonstrating that the removal of fossil fuels from a portfolio does not appear to harm performance [6]. Guo et al. studied three industries-aviation, retail, and e-commerce, as well as a portfolio of typical companies in each of the three industries: Delta Airlines, Walmart and Amazon [7]. Ahzari and Kvazirian studied the optimal portfolio formed by the agricultural enterprises of the 32 most important enterprises in Tehran Stock Exchange [8]. Mo studied the performance of venture portfolios in the US aviation industry and pointed out that the pandemic had a large impact on the aviation industry [9]. Chen, Zan, Wang and Ye chose 10 S&P 500 index stocks that represent five links in the energy business chain, and recommended strategy that can help to arrange the energy sector optimally and distribute foreign exchange energy assets [10]. In domestic research, Liu conducted in-depth research on the relationship between portfolio size and risk and risk composition in the financial industry from an empirical perspective [11]. Using the three-factor Fama-French model, Zang selected 28 listed enterprises in the household appliance industry as the research objects, constructed the portfolio and calculated the changes in the rate of return [12]. Wen and Yin studied the financial data of 80 listed companies in the pharmaceutical and biological industry and constructed a portfolio to test the stock returns of this industry [13]. Xu and Yang studied the issue of investment portfolio selection with 25 Chinese media companies active in the stock market [14].

In this paper, the Monte Carlo method is used to perform 100,000 stochastic portfolio simulations formed by these seven stocks, and the effective set of portfolios is obtained and visualized. By using the mean-variance model, the composition of the minimum variance portfolio and the maximum Sharpe ratio portfolio is obtained, and the return and volatility of the two portfolios are calculated. It is apparent that the financial sector makes up the greatest portion of the minimum variance portfolio, whereas the largest portion of the maximum Sharpe ratio portfolio belongs to the real estate sector. The analysis of the asset weights reveals that the equally weighted and maximum Sharpe ratio portfolios departed from the expectation, and their return performances were below market average. At the same time, equally weighted portfolios were also slightly underperforming the market. It is worth mentioning that among the three portfolios, the minimum variance portfolio obtains the highest investment return, which is higher than the market level.

The structure of this paper is just as follows. The stocks from the seven distinct industries that were chosen to build the portfolio are presented in the second section, along with the data sources that were used. The third section describes the adopted model as well as the methodology and introduces the generation and screening of optimal portfolios. Conclusions and discussions are drawn in the fourth and fifth sections.

2. Data

This paper selected 7 representative stocks from different industries and sectors in the Chinese market, which is beneficial to diversify portfolio risks as well as reduce the correlation coefficient of each stock in the portfolio. They are WankeA (000002), Ningdeshidai (300750), Guizhoumaotai (600519), Dongfangcaifu (300059), Zhaoyichuangxin(603986), Zhongguopingan(601318), Yaominggkangde (603259).

The data used in this paper about their closing price for 59 trading days from January 4, 2022, to April 1, 2022, comes from Sohu Securities(https://q.stock.sohu.com/index.shtml). After importing the obtained data into Python3, the mean function in numpy library was used to estimate the expected

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annualized return of each stock. The following Table 1 and Fig. 1 display various descriptive facts about these assets.

Table 1: Descriptive statistics of the selected assets.

	WankeA	Ning-deshidai	Gui-zhoumao-tai	Dong-fangcaifu	Zhaoyichuangxin	Zhongguo pingan	Yaoming-kangde
Mean	0.0858	-0.3294	-0.4600	-0.7489	-0.6238	-0.1625	0.0108
Vari-ance	0.2572	0.2832	0.1305	0.2563	0.2381	0.1187	0.3870
Max	0.0345	0.0861	0.0449	0.1042	0.0528	0.0534	0.1000
Min	-0.0802	-0.0750	-0.0571	-0.1336	-0.0531	-0.0690	-0.0999

From the data showing above, this paper finds that the highest average return is appeared in 'WankeA' at 0.0858, while the lowest average return is -0.7489 from 'Dongfangcaifu'. Comparing their variances, 'Yaomingkangde' has the largest variance while 'Zhongguopingan' has the lowest. In addition, the lowest max return is shown in 'WankeA', but the lowest min is shown in 'Dongfang-caifu'. What's more, the highest max return is shown in 'Dongfangcaifu' while the lowest min return is also shown in this stock.

Figure 1: Cumulative returns of the seven stocks.

3. Method

3.1. Minimum Variance Portfolio

Formed by setting different weights for different stocks in the portfolio, a portfolio with the least amount of volatility and risk is called a minimum variance portfolio, which is created by allocating different weights to various equities within the portfolio. It is a common implementation form of low volatility strategy, and it has played an increasingly important role in the real investment market. Although it is clear that many classical financial theories, including CAPM and APT, hold the belief that the investors' expected rate of return is strictly positive correlated with the risks they take, in fact, many empirical experiences have proved that There is no linear link between risk and return [15]. Not only do stocks with high volatility have a higher rate of future returns, but also stocks with low

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volatility have particularly high future returns in some cases [16]. The minimum variance approach takes into account the increased focus of the financial crisis on risk management, the historical tendency of low volatility stocks to generate returns that match or outperform the market, and the historical tendency of low volatility stocks to reduce volatility [17]. The mathematical expression of the apparent minimum variance portfolio is as follows.

$$\min x^T wx$$
$$s.t.\begin{cases}\Sigma x_i = 1\\ x_i \geq 0\end{cases} \tag{1}$$

Where is a matrix representing the covariance between the returns of each item in the portfolio; x is the column vector of the weight of each stock in the portfolio; The limitation requirement $\Sigma x_i = 1$states that the total weights of all assets equal one; The constraint condition $x_i \geq 0$ indicates that the weight of each asset is non-negative, that is, short selling is prohibited in the portfolio. The goal of this strategy is to minimize the volatility of return of the portfolio. It's the sole portfolio that is set upon this efficient frontier and is not predicated on the expectation of a return.

3.2. Maximum Sharpe Ratio Portfolio

In the stock market, portfolio methods that produce outstanding Sharpe ratios are highly prized [18]. The Sharpe ratio of a portfolio that has been built to the highest possible level is known as the maximum Sharpe ratio portfolio. A crucial metric to gauge a portfolio's return and risk is the sharpe ratio, which is calculated as the ratio of the excess return to the standard deviation. A higher Sharpe ratio indicates that investors can get higher return with lower risk. On the contrary, the investor may take on even more risk if the Sharpe ratio is low in order to get a higher return. Investors can take into account both portfolio's earnings and risk in the objective function of the optimization problem through maximizing the Sharpe ratio, which gives the model high economic interpretation capability. The apparent form of maximum Sharpe ratio portfolio has the following mathematical representation:

$$E(r_p) = \Sigma x_i \mu_i$$
$$\max \frac{E(r_p) - r_f}{\sigma_p}$$
$$s.t.\begin{cases}\Sigma x_i = 1\\ x_i \geq 0\end{cases} \tag{2}$$

Where x_i represents the weight of the i-th stock in the portfolio； μ_i represents its anticipated annualized return of the i-th stock ; The annualized risk-free rate of return is r_f , while the portfolio's annualized return standard deviation is σ_p; The constraint condition $\Sigma x_i = 1$ still indicates that the sum of all asset weights equals to one; The constraint condition $x_i \geq 0$ also indicates that the weight of each asset is non-negative, that is, short selling is prohibited in the portfolio. The majority of practical circumstances may be accommodated by this model, and it is also straightforward enough to be used for theoretical analysis as well as numerical solutions [19].

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3.3. Equally Weighted Portfolio

An equally weighted portfolio is one in which all assets are assigned equal weight, with each item having a weight equal to 1/n. Building an equally weighted portfolio is convenient because it does not require the estimation of unknown parameters or the use of technical methods to optimize the asset weight allocation of the portfolio. equally weighted portfolios, also known as '1/n' portfolios, are commonly employed in practice and have proven to be effective out-of-sample [20].

3.4. Monte Carlo Simulation

Monte Carlo method is to obtain the real simulation of the general situation through the simulation of a large number of random data, so as to obtain the decision-making results of solving complex problems. In this paper, the annualized return and covariance matrix of stocks are taken as parameters, and Monte Carlo method is used to simulate and create a large number of portfolios with different stock weights. Through doing this, the data pool can represent the most possible asset allocations and can be used for plotting out the efficient frontier.

4. Results

100,000 simulations had been performed using the Monte Carlo method in Python3, according to the earning data of seven stocks from January 4th, 2022, to April 1st,2022. Here, the expected return of the portfolio is the weighted sum of the expected returns of 7 stocks, and the risk-free interest rate is left at 1.1% when estimating the Sharpe ratio, which is the benchmark interest rate for a 3-month fixed deposit in 2022. The expected returns and volatility of these portfolios are shown below (Fig. 2).

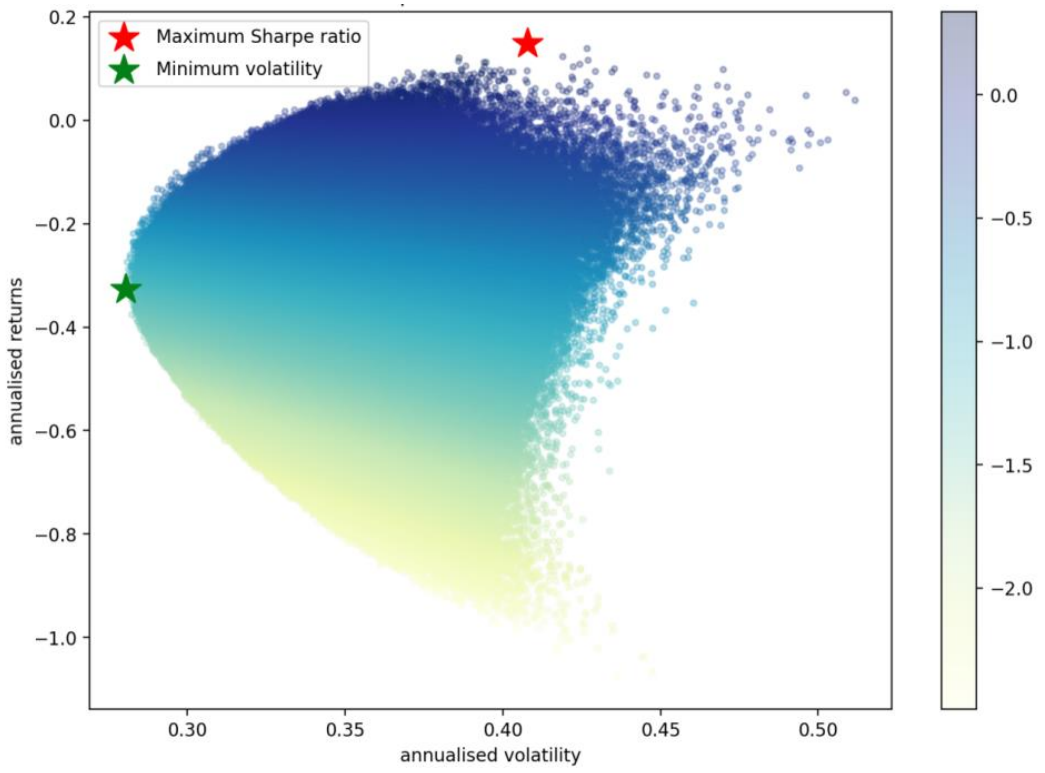

Figure 2: Efficient frontier retrieved by Monte Carlo Method.

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As is shown in the figure, the randomly generated portfolio presents a sector area. This region is called the feasible set, and the boundary to the left of the feasible set is called the efficient set, frequently referred to as the efficient frontier. The portfolios which provide the greatest return with the same risk, or the least risk for the same payoff, are those that are on the efficient frontier. The minimum variance portfolio, which lies in the efficient set's very leftmost corner, may be found using the mean variance model. We can also find the maximum Sharpe ratio portfolio, which is the one with the maximum excess return for every risk unit and the one with the least amount of risk per additional return unit. The calculated portfolio weights and the Sharp ratio and the volatility are in the following Table 2 and Table 3.

Table 2: Asset weights under two criterions.

	WankeA	Ningdeshidai	Guizhoumaotai	Dongfangcaifu	Zhaoyichuangxin	ZhongGuopingan	Yaomingkangde
MVP	0.05%	1.85%	30.28%	0.31%	13.18%	45.95%	8.38%
MSRP	58.87%	0.16%	0.49%	0.76%	1.08%	0.67%	37.97%

Table 3: Portfolio characteristics of the two portfolios.

	Annualized Return	Annualized Volatility
Minimum Variance Portfolio	-0.33%	0.28%
Maximum Sharpe Ratio Portfolio	0.15%	0.41%

According to the information in the above table, it is easy to see that the weights of each asset in the portfolio built using the minimum volatility strategy and the greatest Sharpe ratio strategy change extremely noticeably. In the minimum variance model, Zhongguopingan has the largest weight of 45.95%, which is almost half of the entire portfolio. WankeA, which has the smallest weight, accounts for only 0.05%. In the maximum Sharp ratio model, WankeA occupies the most important position in the portfolio with a weight of 58.87%, followed by Yaomingkangde with a weight of 37.97%, while Ningdeshidai, Guizhoumaotai, Zhaoyichuangxin and Zhongguopingan all occupy a very low weight of less than 1%.By comparing the weights of each asset in the two portfolios, it can be found that the weights of WankeA and Zhongguopingan are quite different, while the weights of Ningdeshidai and Dongfangcaifu are similar and small in the two portfolios.

After obtaining the asset allocation of the two portfolios, we can use the closing prices of each asset in the portfolio from April 6 to May 11, 2022, as a test set and, together with the weight of the assets, calculate the cumulative return rate of the portfolio during this period. For comparison, the closing prices of the CSI 300 index during the same period were also collected. The CSI 300 index measures the general trend of the Shanghai and Shenzhen markets, which account for the majority of the floating market value, are used to choose the index samples. The component stocks are common stocks used in mainstream investments that have strong market representation, high levels of liquidity, and active trading that can capture the performance of common investments in the market. In this paper, it is hypothesized that one million yuan is invested in the CSI 300 index, the portfolio with the

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highest Sharpe ratio, the portfolio with the lowest variance, as well as the portfolio with equal weights. The final returns of each portfolio are compared, as shown in the Fig.3, Fig. 4 and Fig. 5.

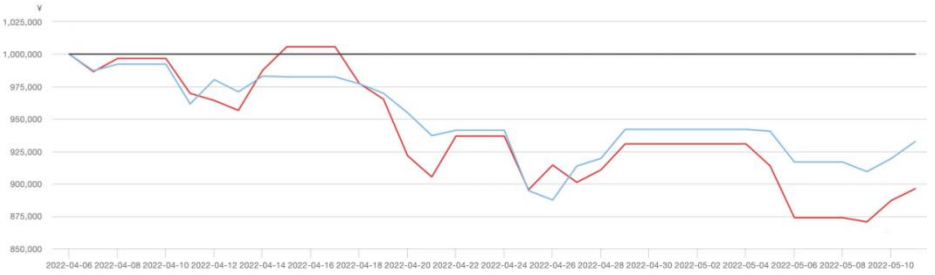

Figure 3: Comparison of maximum Sharpe ratio portfolio and the market level.

The blue line in this graph reflects the cumulative return of the CSI 300 index, while the red line in this graph represents the cumulative return of the maximum Sharp ratio portfolio.The cumulative return for the highest Sharpe ratio portfolio is -5.87%, compared -6.74% for the CSI 300 index. It is evident that the Maximum Sharpe ratio portfolio's return record seems to be no better than the market average. The portfolio with the highest Sharpe ratio has a cumulative return of -5.87%, compared -6.74% for the CSI 300 index. It is evident that the Maximum Sharpe ratio portfolio's return record is no better than the market average.

Figure 4: Comparison of minimum variance portfolio and the market level.

However, for the portfolio with the least variance, the cumulative return is -10.38 %. As can be seen from the figure, the cumulative returns of the portfolio with least return and the CSI 300 index have essentially the same change direction and amplitude, however the minimum variance portfolio's returns have consistently been marginally greater. Moreover, the portfolio with the lowest variance beat both the market and the portfolio with the highest Sharpe ratio.

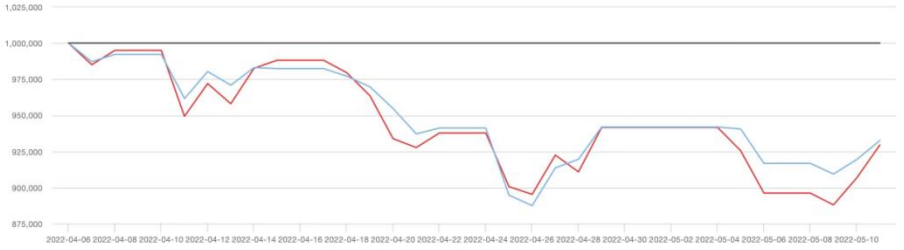

Figure 5: Comparison of equally weighted portfolio and the market level.

As for equally weighted portfolio, it produces an overall return of -7.06%, which is a little bit lower than the market level. Even though it performs better than a portfolio with the highest Sharpe

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ratio, its cumulative return is still lower than that of the CSI 300 index and the minimum variance portfolio.

5. Conclusion

In summary, three portfolios comprised of seven stocks from the China A-share market were evaluated and observed in this paper: the minimal variance portfolio, the highest Sharpe ratio portfolio, and the evenly weighted portfolio. The empirical results in this paper can be summarized as follow. First, Zhongguopingan, which accounts for nearly half of the portfolio, has the highest weight in the minimum variance model at 45.95%. With a weight of 58.87%, WankeA holds the top spot in the portfolio in the maximum Sharp ratio model. Second, in the market backtest, the minimum variance portfolio created using the minimum volatility method outperformed all others, with a cumulative return rate of -5.87%, exceeding the performance of CSI 300 index in the same period. The maximum Sharpe ratio portfolio returns do not outperform the market level and the minimum variance model, mainly because the statistics that were used to select the optimal portfolio and the data used in the backtest in the market come from different periods. With the change of time, the return of each asset in the market is also changing. Therefore, in the stage of pessimistic market sentiment, the portfolio with the least variance can reduce the portfolio's volatility and has a greater chance of obtaining slow but consistent and stable returns over time, which is a more desirable and recommended asset allocation strategy when the market environment is unfavorable.

However, this paper is also inferior to research. In this paper, the greatest Sharpe ratio portfolio and the smallest variance portfolio are both built using simply the mean-variance mode. There are some restrictions in the foundation for determining the weight of each stock when constructing a portfolio as this model believes that investors only base decisions on the risk and return of equities.

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