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Portfolio Optimization for Industries in China's A-shares Market

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Abstract: Portfolio optimization has always been a hot topic in financial research. Rational investors seek to balance risk and return in asset allocation. This article conducts a portfolio analysis of the military, liquor, new energy vehicles, medical service, and real estate industries in Chinese market. We select a representative asset from each industry and construct a large number of portfolios using the mean-variance model. Among the efficient frontier, we mainly focus on two portfolios. One is the minimum variance portfolio, and the other is the tangency portfolio. Finally, we compare these two portfolios to the SCI 300 Index. The results show that the real estate industry has the largest proportion in the minimum variance portfolio and the military industry contributes most to the maximum Sharpe portfolio. These two portfolios perform better than the SCI 300 Index.

Keywords: Mean-Variance model, Sharpe ratio, portfolio selection and optimization

1. Introduction

The mean-variance portfolio theory which is put forward by Markowitz in 1952 quantifies risk and helps investors choose efficient portfolios with a higher return at a specific level of risk or a lower risk level under a specific level of return among all possible portfolios. These efficient portfolios constitute the Markowitz efficient frontier. The portfolio selection problem based on the mean-variance efficient frontier is essentially a dual-objective optimization problem [1]. This model pioneers modern portfolio theory [2]. After the mean-variance model, models such as the capital asset pricing model proposed in 1960s and the arbitrage pricing theory put forward in 1976 use econometric methods to improve the portfolio theory from different perspectives, so that the modern portfolio theory has been developed rapidly [3]. For investors, a major part of financial decision-making and management is portfolio selection [4]. Building a low-risk and high-return portfolio has always been the goal of investors.

After reading numerous pieces of literature, we find that most of the current research on portfolio optimization and management focuses on analyzing a single industry or an entire stock market. However, there is little portfolio analysis of the military, liquor, new energy vehicles, medical service, and real estate industries in China. Liu adopted the CVaR method to measure the risk of a real estate investment portfolio and established the optimal portfolio theory of real estate investment under the condition of risk minimization [5]. Research by Wang et al. analyzed the portfolio optimization problem of the power generation technology [6]. Wu et al. identified potentially well-performing stocks and constructed investment portfolios by constructing a statistical prediction model of stock

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selection in China's stock market [7]. Moreover, some researchers compared the stock market performance of different countries. Research by Ni et al. observed the profitability of stock investment and explored whether investors can profit from technical trading strategies based on the stock market data of China and South Korea [8]. After COVID-19 began to have a huge impact on the global society and economy, a large number of research directions turned to how the global pandemic impacts the stock market. Wu, Lee, Xing, and Ho studied how COVID-19 impacts the trends of stock price on China's tourism industry [9]. Jin explored the short-term and long-term effects on the volatility of daily stock price in China at the beginning of the pandemic and during the pandemic [10].

The research process of this article is summarized as follows. First, we select 5 representative assets from China's military, liquor, new energy vehicles, medical services, and real estate industries. Collect daily stock data of these assets from July 01, 2020, to July 01, 2022. Secondly, we convert raw data to time-series data and calculate the daily returns. Thirdly, we use the Markowitz mean-variance model to construct a large number of portfolios for the selected assets, screen the efficient portfolios located on the Markowitz efficient frontier, and obtain the minimum variance portfolio. After calculating the Sharpe ratio of the efficient portfolios, we get the maximum Sharpe portfolio which is also known as the tangency portfolio. Then, based on their weights, we obtain the time-series data for these two portfolios from July 01, 2021, to July 01, 2022. Finally, we compare the minimum variance portfolio which has the lowest risk and the tangency portfolio which has the highest Sharp ratio with the SCI 300 Index over the same time interval to analyze their performance in Chinese stock market.

2. Data and Methods

2.1. Data Selection

The assets we choose in this article are China Zhenhua (Group) Science & Technology Co., Ltd., Wuliangye Yibin Co., Ltd, Yunnan Energy New Material Co., Ltd., Hangzhou Tigermed Consulting Co., Ltd., and Poly Developments and Holdings Group Co., Ltd. They are the leading companies in the military, liquor, new energy vehicles, medical services, and real estate industries in China. All five assets are quoted and traded in the Chinese yuan renminbi (CNY). We use these five bellwether assets to represent the trend of industries and download their daily historical data from July 01, 2020, to July 01, 2022, on Yahoo Finance (https://finance.yahoo.com/).

Table 1: Selected assets.

Industry	Company	Stock code
Military Industry	China Zhenhua (Group) Science & Technology Co., Ltd.	000733.SZ
Liquor Industry	Wuliangye Yibin Co.,Ltd.	000858.SZ
New Energy Vehicles	Yunnan Energy New Material Co., Ltd.	002812.SZ
Medical Service	Hangzhou Tigermed Consulting Co., Ltd.	300347.SZ
Real Estate	Poly Developments and Holdings Group Co., Ltd.	600048.SS

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2.2. Data Preprocessing and Understanding

We first use adjusts closing prices to calculate the daily returns for these assets and transfer them to logarithmic returns. Then, we convert the returns into time-series data and calculate some important descriptive statistics for each asset. Part of the statistics is shown in Table 2. From Table 2, 'Zhenhua' has the highest average return, while 'Wuliangye' has the lowest average return. There is not a big difference between the returns of 'Tigermed' and 'Poly', but 'Tigermed' has a higher standard deviation than 'Poly'. 'Poly' has the lowest standard deviation, while 'Zhenhua' has the highest. Moreover, 'Zhenhua' has the highest maximum return, while 'Tigermed' has the lowest. 'Poly' has the highest minimum return, while 'Tigermed' has the lowest. To sum up, among these five assets, 'Zhenhua' has a higher risk and return. 'Wuliangye' and 'Poly' are low-risk and low-return assets.

Table 2: Descriptive statistics of the selected assets.

	Zhenhua	Wuliangye	Energy	Tigermed	Poly
Mean	0.00374	0.00027	0.00272	0.00033	0.00032
Std. dev	0.03620	0.02659	0.03440	0.03380	0.02494
Max	0.09787	0.09530	0.09533	0.09423	0.09559
Min	-0.10540	-0.10645	-0.10537	-0.11784	-0.10509

2.3. Covariance

Table 3 indicates the covariance between the logarithm returns of these five assets. We can find that 'Poly' has negative covariance with Zhenhua, Energy, and Tigermed, while other assets have positive covariance with each other.

Table 3: The covariance matrix for selected assets.

	Zhenhua	Wuliangye	Energy	Tigermed	Poly
Zhenhua	0.33020				
Wuliangye	0.04110	0.17810			
Energy	0.07850	0.06960	0.29820		
Tigermed	0.06070	0.11190	0.11020	0.28800	
Poly	-0.00100	0.01600	-0.01300	-0.00540	0.15670

2.4. Time Series

Figure 1 shows the time-series plots of these five assets. There are no obvious patterns or cyclic movements. However, it is worth noting that the volatility of 'Poly' increases from August 2021.

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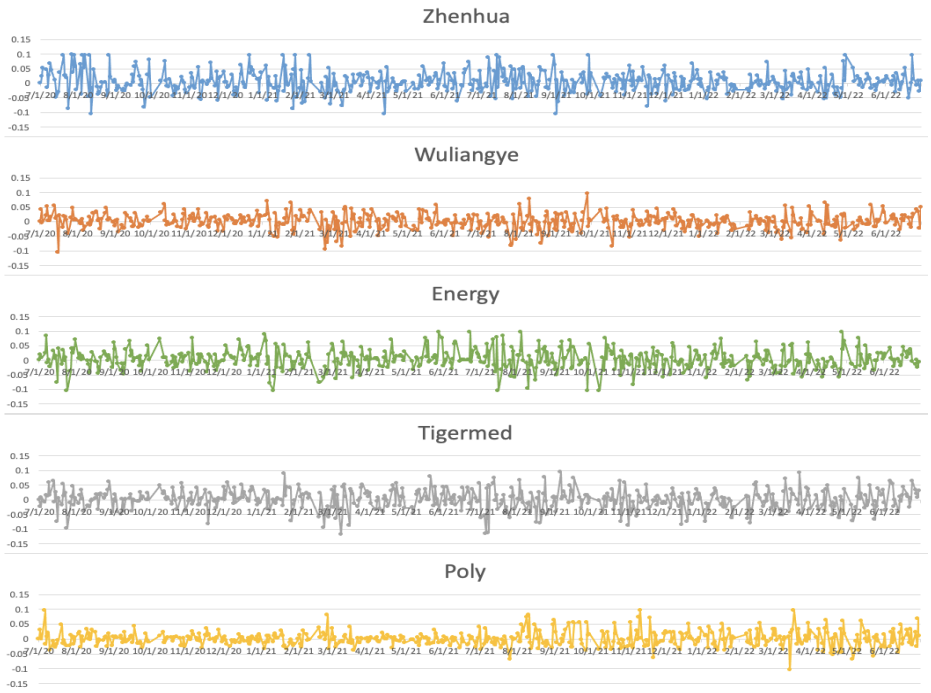

Figure 1: Time-series plots of selected assets.

2.5. Mean-Variance Analysis

We randomly construct 5000 portfolios of these five assets. Next, we calculate the annualized returns and annualized standard deviations of these portfolios. In this article, we use the standard deviation to represent the risk of a portfolio. Then, we select and reserve the portfolios on the Markowitz efficient frontier from these 5000 portfolios. The total weight of the assets is,

$$\Sigma \ Weight_i \ = \ 1 \tag{1}$$

Where $Weight_i$ denotes the weight of the $Asset_i$ in a portfolio. The portfolio return is calculated as,

$$Portfolio \ Return \ = \ \Sigma \ Weight_i \cdot \ Asset \ Return_i \tag{2}$$

Where $Asset \ Return_i$ is the time series data of $Asset_i$. The portfolio expected return is calculated as,

$$E \ [Portfolio \ Return] \ = \ \Sigma \ Weight_i \ \cdot \ E \ [Asset \ Return_i] \tag{3}$$

Where $E \ [Asset \ Return_i]$ indicates the expected return of $Asset_i$. The variance of the portfolio return is,

$$Var \ [Portfolio \ Return] \ = \ \Sigma Weight_i \cdot \ \Sigma \ Weight_j \tag{4}$$

The portfolio return's standard deviation can be calculated as

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$$s\ [Portfolio\ \ Return]\ = Var\ [Portfolio\ \ Return]^{1/2} \quad (5)$$

2.6. Sharpe Ratio

The portfolio's Sharpe ratio can be calculated as,

$$Sharpe\ \ Ratio\ = (E\ [Portfolio\ \ Return] - R_f)\ /\ s\ [Portfolio\ \ Return] \quad (6)$$

Where the risk-free rate is denoted by R f. In this article, we take 2.8264% as the risk-free rate, which is the yield on China's 10-year government bond by July 01, 2022, retrieved from China Foreign Exchange Trade System (https://www.chinamoney.com.cn/chinese/index.html). We calculate the Sharpe ratios for the portfolios on the Markowitz efficient frontier. Then, we can obtain the portfolio with minimum variance and the portfolio with the maximum Sharpe ratio.

2.7. Test the Efficiency of the Portfolios

Finally, with the weights of the portfolios, we can obtain the daily logarithm returns for the portfolios we focus on from July 01, 2021, to July 01, 2022. Then, we calculate the annualized return and the annualized standard deviation for these two portfolios. After that, we compare the portfolio with the lowest risk and the tangency portfolio with the CSI 300 Index in the same period to see if the portfolios we build can have a good performance.

3. Results

Table 4 shows the weight distributions among the assets in the minimum variance portfolio and the tangency portfolio. In the first portfolio, 'Poly' has the largest weight which is about 42.28%. The weight of 'Tigermed' is the lowest and accounts for about 10.63%. The weights of 'Zhenhua', 'Wuliangye', and 'Energy', about 15.92%, 16.56%, and 14.62% respectively, are close to each other. In the maximum Sharpe portfolio, 'Zhenhua' distributes approximately 57.75%, which is a high proportion. 'Energy' has the second-largest weight, accounting for about 27.69%. While 'Wuliangye', 'Tigermed', and 'Poly' all have pretty small weights in this portfolio, about 5.45%, 1.89%, and 7.21%, respectively. We can obvious that the dominated assets are different in the minimum variance portfolio and the portfolio with the highest Sharpe ratio. 'Poly' and 'Wuliangye' account for most in the first portfolio, while 'Zhenhua' and 'Energy' account for most in the second portfolio. 'Tigermed' contributes little to both portfolios.

Table 4: Asset weights of the portfolios.

	Zhenhua	Wuliangye	Energy	Tigermed	Poly
Min Variance	0.15915	0.16557	0.14620	0.10633	0.42284
Tangency	0.57751	0.05452	0.27691	0.01892	0.07215

Table 5 indicates the returns, risks, and Sharpe ratios of the portfolio with the lowest risk and the tangency portfolio. The annualized return of the first portfolio is about 35.55% and the annualized return of the maximum Sharpe portfolio is about 110.49%. We use their annualized standard deviations to measure the risks of these two portfolios. The Sharpe ratio of these two portfolios is both more than 1. The second one is even higher than 2. We consider the first Sharpe ratio acceptable to good and the second Sharpe ratio is rated as very good.

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Table 5: Returns, risks, and Sharpe ratios of the portfolios.

	Return	Risk	Sharpe Ratio
Min Variance	0.35545	0.26363	1.24101
Tangency	1.10493	0.40799	2.63897

Figure 2 shows the time-series plots for the daily returns of the portfolio with the minimum variance, the tangency portfolio we build, and the CSI 300 Index. From the figure, we can observe clearly that the volatility of the CSI 300 Index increases after March 2022, though that is much smaller than these two portfolios before March.

Figure 2: Time-series plots for the daily returns of the portfolios and the CSI 300 Index.

From Table 6, we can find that although the CSI 300 Index has the lowest risk compared to the minimum variance portfolio and the tangency portfolio, its return and Sharpe ratio are both negative. While the portfolios we build still have high returns and good Sharpe ratios.

Table 6: Returns, risks, and Sharpe ratios of the portfolios, and the CSI 300 Index.

	Return	Risk	Sharpe Ratio
Min Variance	0.37980	0.28056	1.25301
Tangency	0.93029	0.38941	2.31635
CSI 300	-0.13097	0.19773	-0.80534

4. Discussion

The portfolio with the lowest risk and the portfolio with the highest Sharpe ratio allocates the largest proportion of capital to the real estate industry and military industry, respectively. The negative covariance between the real estate and military, new energy vehicles, and medical service industries

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enhances portfolio diversification and reduces volatility. Diversification can greatly reduce the risk of a portfolio [11]. Thus, it makes sense that the real estate industry has the heaviest weight in the minimum variance portfolio. For the Chinese arms industry, Chinese President Xi Jinping proposed to realize the modernization of national defense and military by 2035 in the 19th National People's Congress [12]. This provides a great guarantee for the steady growth of the military industry. According to SINA Finance, since 2019, the net profit growth rate of CSI NATIONAL DEFENSE (399967.SZ) has remained at a relatively high level, mainly due to the rebound in military spending and the support of defense policies. The net profit growth rate in 2020 is as high as 61.66%, and it is expected to maintain a growth rate of 39.62% and 23.73% in 2022 and 2023 respectively. The representative company in the military industry we selected, 'Zhenhua', has the highest Sharpe ratio among 5 assets, which is about 2.67. The excellent performance of the military industry makes it occupy an important position in our maximum Sharpe portfolio.

5. Conclusion

Currently, most research on portfolio optimization and management focuses on analyzing specific industries or an entire market. Our research selected 5 industries that are currently performing well in China's A-shares market, the military industry, liquor industry, new energy vehicles industry, medical service industry, and real estate industry, for portfolio analysis. We use the mean-variance model to construct the efficient frontier and then get the minimum variance portfolio and the tangency portfolio. This step of the study concludes that real estate and military industries have the highest proportions in the minimum variance portfolio and the tangency portfolio, respectively. In addition, we also compare these two portfolios with the SCI 300 Index and find that the portfolios we constructed have better market performance than the SCI 300 Index.

However, our study has certain limitations. We used one bellwether asset in each industry to construct the portfolios. Although highly valued companies usually have a high market share and can reflect the trends of their industry well, the analysis of the entire industry cannot rely solely on one company. Emerging companies may show more growth and be smart investments, while focusing only on bellwether assets may misinterpret this potential. In addition, we should take into account the pandemic can be a challenge or an opportunity for different industries. The abnormal returns of the Chinese stock market were significantly negative after the pandemic started and did not turn positive until May 2020. While the stock data we used starts in July 2020, COVID-19 still impacts people's lives, factory production, transportation and other economic activities. The pandemic has led to a massive reduction in services and consumer industries that depend on people's travel, such as accommodation and catering, but the increase in pharmaceuticals and internet services has brought a huge boom in the pharmaceutical and telecommunications industries. Therefore, as the impact of the pandemic wears off, the weights of the liquor industry and the medical service industry in the minimum variance portfolio and the portfolio with the highest Sharpe ratio may differ from our results.

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