Portfolio Analysis with Mean-Variance Model in Chinese Stock Market

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Abstract. Portfolio optimization is crucial in the financial sector. The goal of this article is to analyze portfolio allocation in the Chinese stock market. This article's information was taken from Straight Flush. To obtain a greater hedging impact, we choose firms from other sectors in order to lessen the connection between their stocks. The data was analyzed using the Efficient Frontier, Modern Portfolio Theory, and Mean-Variance Model. The annualized returns of Bank of China and Maanshan Iron and Steel are negative, according to the results. Maanshan Iron and Steel is -0.029148 vs -0.068115 for the Bank of China. Great Wall Electricity is 0.173349, whereas BYD is 0.250717 and MIDEA is 0.117577. The volatility of these five equities is substantial. The Bank of China's annualized volatility is 0.34952. The portfolio with the least volatility has a cumulative return of 18.10%, and the portfolio with the largest Sharpe ratio has a cumulative return of 30.80%. This research has certain reference value for investors.

Keywords: Mean-Variance model, portfolio, Chinese stock market.

1. Introduction

Recently, portfolio optimization is a widely used way to manage the financial risk of portfolios. Usually, a financial analyst is targeted to the minimum volatility at a given return or the maximum return at certain volatility [1]. Since the resources available to capital investors are very limited, how to optimize the investment portfolio has become one of the most concerning issues for investors. American economist Harry M. Markowitz proposed the Mean-Variance Model, which measures risk by the variance of the portfolio and has become one of the most essential tools for portfolio optimization. A portfolio is constructed by the composition of securities and certain weights, and the securities selected should be irrelevant [2]. And a diversified portfolio may enable investors to obtain higher returns at the same risk [3].

Nowadays, studies about portfolio optimization are abundant. However, there is still a lack of research on China's capital market and multi-industry portfolio. Most portfolio analysis is on the basis of the overall market environment. For example, Li Bo and Teo Kok Lay studied portfolio optimization problems when investors constructed portfolios in a market that contains many uncertainties [4]. Kenig Eyal researched how to do the portfolio selection in a volatile market [5]. And, some researchers studied a few specific industries. For example, Hernandez, Kang and Yoon researched the portfolio of precious metal commodities and equity markets [6]. Sarah, Daniel, and Christopher did the portfolio optimization focusing on the US household industry [7]. Sharafi, Nourollahzadeh and Sarraf studied the issue of investment portfolio selection and focused on the pharmaceutical and steel industries [8].

The intention of this paper is to analyze the portfolio of five companies that are selected from five different industries i.e., bank industry, steel industry, automobile industry, household appliance industry, and energy industry. The empirical process in this paper is as follows. At first, five stocks from the banking, steel, auto, and white-goods sectors of the A-share market are selected for their closing prices between January 5, 2015 and December 30, 2016. Second, we do some rudimentary

studies on the chosen stocks, such calculating the covariance matrix for the five stocks. Finally, we simulate ten thousand portfolios using Monte Carlo simulation to get a complete list of all imaginable portfolios. Then, the minimal volatility portfolio and the greatest Sharpe ratio portfolio are derived from the Feasible Set of the portfolio. Finally, the capacity to obtain returns from the two portfolios is evaluated, and the best portfolio is found, by comparing the cumulative returns of the two portfolios and the Shanghai Compositive Index.

2. Data

Straight flush (https://www.10jqka.com.cn/) is the source for the statistics used in this piece. Bank of China (601988), Maanshan Iron and Steel (600808), BYD (002594), Midea (000333), and Great Wall Electric (600192) for closing prices from January 5, 2015, to December 29, 2017, are among the companies chosen in this paper to reduce the correlation of these stocks and thus achieve a better hedging effect. A total of 3665 records were gathered. These companies play significant roles in their respective sectors. The unique financing arrangement of BANK OF CHINA and MAANSHAN IRON AND STEEL ensures its continued viability. It is possible to make a lot of profits off of BYD and MIDEA. Converted these daily closing prices to a return for the day by:

$$L_t = \frac{V_{t+1}}{V_t} - 1 \quad (1)$$

There were two ends to which these numbers were put. The model was constructed and trained using data collected from January 5, 2015 through December 30, 2016. Using 2017 data, we utilized the model-recommended weights to determine this portfolio's return. Then In this research, we compare the model's performance to the average market return as measured by the Shanghai Stock Exchange Index. Tabulated below is some background data.

Table 1. Descriptive statistics of the selected stocks

	BANK OF CHINA	MAANSHAN IRON AND STEEL	BYD	MIDEA	GREAT WALL ELECTRICAL
Mean	-0.00027	-0.00012	0.00102	0.00047	0.00069
Standard Deviation	0.02202	0.03497	0.03435	0.03267	0.03883
Max	0.10000	0.10131	0.10011	0.10016	0.10075
Min	-0.10978	-0.10072	-0.10002	-0.38315	-0.10047

The ‘BYD’ has the highest average daily return, while the ‘BANK OF CHINA’ has the lowest daily return. When it comes to standard deviation ‘BANK OF CHINA’ is the lowest, while ‘GREAT WALL ELECTRICAL’ is the highest.

3. Methods

3.1. Modern Portfolio Theory

Markowitz, an American economist, created the Mean-Variance Model in 1952 [9-10]. To describe investors' preferences, explain the idea of investment diversification, and systematically expand on the issue of asset portfolio and selection, Modern Portfolio Theory is the first theory to use the notions of mean and variance of portfolio returns (MPT). This idea proposes that portfolios may mitigate systemic risk. The selection of unrelated securities should be the purpose of portfolio development, since the portfolio's composition and weights are dictated by the securities' composition and weights.

3.2. Mean-Variance Analysis

Mean-variance analysis is a mathematical method for allocating assets with the stated objectives of either increasing the anticipated return or decreasing the risk for a group of investors. Mean-variance analysis, as described by Rubinstein, has traditionally been used as a method for gauging and building asset portfolios [11].

$$\sum_i \text{Weight}_i = 1 \tag{2}$$

Where is the Weight_i of the Asset_i in the portfolio. Following is a formula for determining the return and variance of a certain portfolio.

$$\text{Portfolio Return} = \sum_i \text{Weight}_i \cdot \text{Asset Return}_i \tag{3}$$

Where Asset Return_i is the compound return of Asset_i's time series data.

$$\text{E[Portfolio Return]} = \sum_i \text{Weight}_i \cdot \text{E[Asset Return}_i] \tag{4}$$

Where $\text{E[Portfolio Return]}$ is the expected return of Stock_i.$\text{E[Asset Return}_i]$ is the expected return of the portfolio.

$$\text{Var[Portfolio Return]} = \sum_{i,j} \text{Weight}_i \cdot \text{Weight}_j \cdot \text{Cov}\left[\text{Asset Return}_i, \text{Asset Return}_j\right] \tag{5}$$

Where Cov denotes the variance-covariance between Asset Return_i and Asset Return_j. Var denotes the variance of portfolio return.

The following equation may be used to determine a portfolio's Sharpe ratio,

$$\text{Sharpe Ratio} = \frac{\text{E}(R_P) - R_f}{\sigma_P} \tag{6}$$

The portfolio's anticipated return is given by (R_P), the risk-free rate is given by R_f, and the portfolio's standard deviation is given by σ_P.

3.3. Efficient Frontier Model

An efficient frontier is a set of investment portfolios that are expected to provide the highest returns at a given level of risk. A portfolio is said to be efficient if there is no other portfolio that offers higher returns for a lower or equal amount of risk [12]. The accurate location of portfolios on the efficient frontier depends on the investor's risk tolerance level. Because of the marginal return to risk is diminishing, the efficient frontier turns out to be a curved line.

4. Results and Analysis

4.1. Pre-processing and analysis of data

This research uses the linear returns formula to calculate these five stocks' daily returns. After that, the paper calculates the covariance matrix of these stocks.

Table 2. Covariance matrix of the selected stocks

	BANK OF CHINA	MAANSHAN IRON AND STEEL	BYD	MIDEA	GREAT WALL ELECTRICAL
BANK OF CHINA	0.0005	0.0003	0.0001	0.0003	0.0001
MAANSHAN IRON AND STEEL	0.0003	0.0012	0.0007	0.0005	0.0009
BYD	0.0001	0.0007	0.0012	0.0005	0.0008
MIDEA	0.0003	0.0005	0.0005	0.0011	0.0005
GREAT WALL ELECTRICAL	0.0001	0.0009	0.0008	0.0005	0.0015

The results show that the correlation of these five stocks is not high almost all lower than 0.001. Then the author use the data of daily return the paper get the annualized returns of the selected stocks.

Table 3. Annualized returns of the selected stocks

Stock	Annualized return
BANK OF CHINA	-0.068115
MAANSHAN IRON AND STEEL	-0.029148
BYD	0.257071
MIDEA	0.117577
GREAT WALL ELECTRICAL	0.173349

Through Table 3 above, it can be concluded that the annualized returns of BANK OF CHINA and MAANSHAN IRON AND STEEL are negative. BANK OF CHINA is -0.068115 and MAANSHAN IRON AND STEEL is -0.029148. The other three stocks are doing better. BYD is 0.257071, MIDEA is 0.117577 and GREAT WALL ELECTRICAL is 0.173349.

Then the author calculates the annualized volatility of these five stocks. The result is that the volatility of these five stocks is all high. The annualized volatility of BANK OF CHINA is 0.34952.

Table 4. Annualized volatility of the selected stocks

Stock	Annualized volatility
BANK OF CHINA	0.349524
MAANSHAN IRON AND STEEL	0.555139
BYD	0.545352
MIDEA	0.518595
GREAT WALL ELECTRICAL	0.616452

According to Table 4, as it shown that the volatility of BYD among the five stocks is relatively low and the annualized return is high. The volatility of BANK OF CHINA is the lowest among these five stocks. So, if the research wants to pursue low risk the paper will hold more shares of BANK OF CHINA. And if the research wants to pursue higher returns BYD is a good choice.

4.2. The Feasible Set

In order to get the feasible set, this paper generates a random set of weights, calculates the return and standard deviation for that combination, and repeats this process 1,000 times. Then this paper plots the results into a scatter plot.

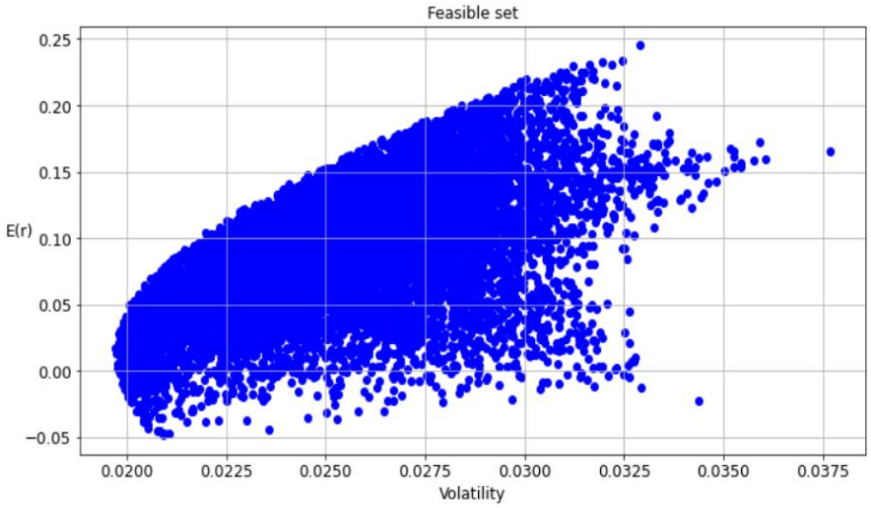

Figure 1. The Feasible Set of the portfolio

Because the annualized returns of BANK OF CHINA and MAANSHAN IRON AND STEEL are negative, the situation that E(r) is negative exists. The maximum E(r) is up to 0.25. The minimum volatility is less than 0.02.

4.3. The Efficient Frontier

The paper can get the efficient frontier according to the feasible set this research have gained.

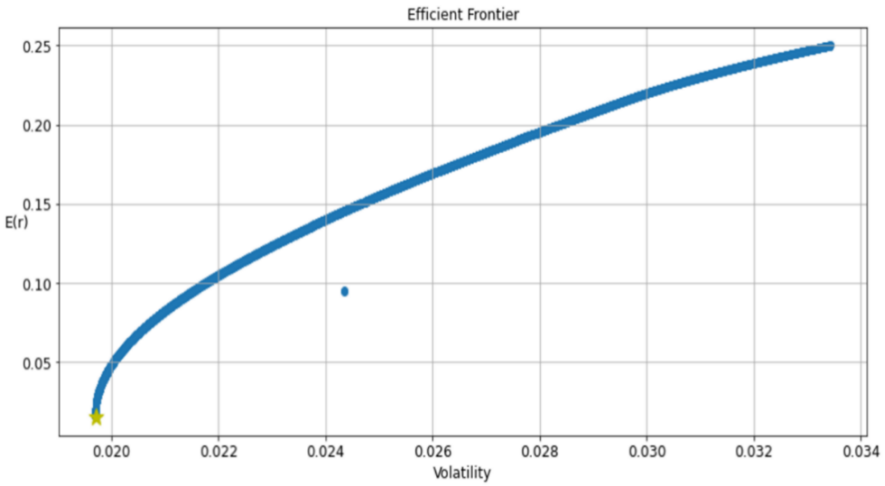

Figure 2. The Efficient Frontier

And the paper drew the capital allocation line. The point where the line intersects the efficient frontier is the point of the maximum Sharpe ratio.

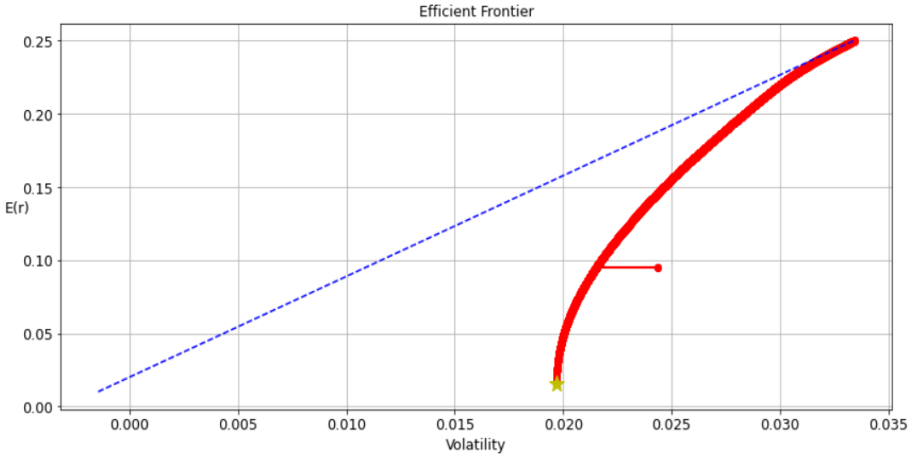

Figure 3. The Capital Allocation Line and the Efficient Frontier

4.4. Two Important Outcomes

As the Mean-variance model assumes that investors have two investment goals: the highest return and the lowest risk. Therefore, the paper analyzes the following two cases.

The first one is the least risky case. In order to get the lowest risk, this research needs to find out the outcome with the lowest volatility, which is 0.0197.

Table 5. The minimum volatility portfolio

Stock	Weight
BANK OF CHINA	0.6900
MAANSHAN IRON AND STEEL	0.0057
BYD	0.1614
MIDEA	0.0638
GREAT WALL ELECTRICAL	0.0780

The Table 5 above tells the weights of the selected stocks in the minimum variance portfolio. Because the volatility of BANK OF CHINA is the lowest, its weight of it is high.

Another case the paper want is to get a relatively high return with relatively low risk. The Sharpe Ratio is a good indicator. If the Sharpe Ratio is higher, the return on risk per unit of risk is higher. So the paper needs to find out the maximum Sharpe Ratio portfolio.

Table 6. The maximum Sharpe Ratio portfolio

Stock	Weight
BANK OF CHINA	3.5366e-16
MAANSHAN IRON AND STEEL	1.1145e-14
BYD	9.9675e-01
MIDEA	3.2441e-03
GREAT WALL ELECTRICAL	0.0000e+00c

The Table 6 above tells the weights of the selected stocks in the maximum Sharpe Ratio portfolio. The maximum Sharp Ratio is 6.8868. Because the volatility of BYD among the five stocks is relatively low and its annualized return is high, the weight of BYD is relatively high.

4.5. Evaluation of the outcomes

After getting the weights of each stock in the portfolio, to verify the performance of the best portfolio, the paper uses the real closing data from January 3, 2017 to December 29, 2017, and apply the respective weights in the optimal portfolio to get the real risk and return performance of the optimal portfolio in 2017, and compare it with Shanghai Securities Composite Index. Shanghai Securities Composite Index refers to the composite index of all the stock prices of Shanghai Stock Exchange, while it is considered the market level of A-shares (https://wiki.mbalib.com/wiki/Shanghai Securities Composite Index). If the return of the optimal portfolio in 2017 is greater than the Shanghai Securities Composite Index, it will be considered effective.

For the minimum volatility portfolio, the paper calculates the cumulative returns of the portfolio and the Shanghai Securities Composite Index, and the results are 18.10% and 6.56% respectively, which means that the return performance of the minimum volatility portfolio is better than the market level.

Table 7. Return of the minimum volatility portfolio

minimum volatility	return of the portfolio	Shanghai Securities Composite Index
1.97%	18.10%	6.56%

For the maximum Sharpe Ratio portfolio, the cumulative return of the portfolio is 30.80%. The return performance of the maximum Sharpe Ratio portfolio is not only better than that of the market level, but also better than that of the minimum volatility portfolio.

Table 8. Return of the maximum Sharpe Ratio portfolio

maximum Sharpe Ratio	return of the portfolio	Shanghai Securities Composite Index
688.68%	30.80%	6.56%

5. Conclusion

Recently, most portfolio analysis is on the basis of the overall market environment or a few specific industries. However, if the selected industries are more irrelevant， the effect of hedging risk is better. And there are limited papers that used the Mean-Variance model to construct portfolios in the Chinese stock market. Because of that, this paper does a portfolio analysis of the bank industry, steel industry, automobile industry, household appliance industry, and energy industry which can provide a reference for investors. The data used in this paper are closing prices, from January 05, 2015, to December 29, 2017.

This paper uses Monte Carlo simulation to generate ten thousand different portfolios and based on this the feasible set and the efficient frontier were drawn. Then this paper used the Mean-Variance mode to optimize the investment portfolio and construct a portfolio that has a maximum Sharpe ratio

and a portfolio with minimum variance. For the maximum Sharpe ratio portfolio, the automobile industry occupies the largest weight. And bank industry occupies the largest weight for the minimum volatility portfolio. Compared with the Shanghai Securities Composite Index, both portfolios have a better return than the market level.

However, deficiencies also exist. For example, because of the difficulty in obtaining data, the time range of data this paper used is not optimal. The industries selected in this paper are limited.

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