

Portfolio Management for Multi-industry

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Abstract. In the financial field, portfolio management is an important measure in the direction of investment or hedging. This paper mainly focuses on the optimization for the portfolio composed of assets from five industries, which is education, banking, automobile manufacturing, parts industry and e-commerce, and considers the allocation of assets to optimize the returns. In this paper, five representative assets from these five industries are selected. The Markowitz efficient frontier is plotted by Monte-Carlo method, using the return data of assets. Then the portfolio is optimized by mean-variance analysis and the maximum Sharpe ratio portfolio as well as minimum variance portfolio can be calculated. Finally, this paper analyzes the performance of the two portfolios, considering the influence of individual assets on the portfolio weight, and uses the Fama-French three factor model to analyze the performance of the portfolio. The results show that PTAIY and PSO from parts manufacturing and education occupy a large proportion in the maximum Sharpe ratio portfolio as well as the minimum variance portfolio. The findings could help investors interested in these five areas.

Keywords: Mean-Variance, FF3, Multi-Industry Investment, Portfolio Optimization.

1. Introduction

In 1952, Markowitz put forward the important conclusion of the mean-variance theory, which played an important role in the subsequent research and analysis of portfolio management for the majority of scholars. Compared with the traditional way of investing in individual assets, the construction of a portfolio has more obvious advantages [1]. The core purpose of portfolio construction is to spread risk. Combining multiple risky assets with poor inter-correlation can significantly reduce unsystematic risk [2]. It not only keeps the effective frontier of portfolio away from risk, but also enables investors with specific risk preferences to obtain more risk returns in the financial market [3]. Therefore, with the increasing maturity of the financial market, the majority of investors in order to obtain a better marginal return on capital and less risk, portfolio management has become an urgent issue for them to consider [4]. Realizing how to allocate portfolio to meet goals for investors is an important application of portfolio optimization. In the process of optimizing portfolio, financial investors should maximize portfolio returns and minimize portfolio risks. In consequence, considering the balance between the above two demands of benefit and risk is meaningful.

Portfolio management has triggered a boom, and measures to optimize the portfolio have been greatly promoted. Researchers have used a variety of methods to analyze the situation of financial markets in many fields. For example, researchers led by Lim use reinforcement learning to achieve dynamic portfolio balance and provide a new understanding for maximizing portfolio returns [5]. Research team led by Farahnaz Omidi apply an efficient dynamic model to optimize the portfolio, showing that the optimal situation is at the equilibrium point of neural network, which provides a new understanding for portfolio management [6]. Researchers led by Yuri Laio T.V. Silva used A multi-objective evolutionary algorithm to study under the framework of mean variance analysis, overcoming the tradeoff between portfolio risk and expected return. Some researchers have conducted studies on the portfolio construction of assets in specific fields [7]. For example, team led by Pfitzner Mariana Savedra studied the case of portfolio optimization of a large energy company in Brazil [8]. Other studies consider the application of a portfolio approach, integrating financial assets from different areas, to study these areas. For example, Mensi Walid and his partner looked at portfolio

management across precious metals, energy, agriculture and other sectors and found that with proper portfolio management, it can effectively reduce market downside risk [9].

However, it can be noted that there is less research on the management of portfolios consisting of financial assets in areas of low industry relevance. Therefore, this paper considers to analyze the portfolio optimization problems related to five fields: education, banking, automobile manufacturing, parts industry and e-commerce. In the research, this paper will consider the selection of representative assets in five different industries to construct the portfolio, and use the mean variance method to analyze the asset weight, risk and benefit of the portfolio. The empirical details are as follows: First, this paper selected representative stocks in five industries, namely, PTAIY, TSLA, PSO, BAC and AMZN, from September 13, 2021 to September 13, 2022, to obtain their closing prices. Secondly, this paper cleaned and preprocessed the data of these financial time series. Third, using the above data, the paper uses Monte Carlo simulation to plot the effective frontier of portfolio construction. Fourthly, this paper uses the mean-variance method to optimize the portfolio, and obtains the maximum Sharpe ratio portfolio and the minimum variance portfolio. Fifthly, this paper uses Fama-French three-factor model to explain the optimized portfolio, considering the impact of market, market capitalization, and book-to-market on portfolio return. At the same time, the Fama-French model can evaluate the efficiency of optimized portfolio.

Here is a summary of the rest. This paper presents the data in the second part, then the methods used is in the third part, and finally the results and conclusions are in the fourth and fifth parts.

2. Data

The data in this article was obtained from Yahoo Finance. (<https://finance.yahoo.com>). This paper selected the following five companies that are representative in different fields, which are PTAIY, TSLA, PSO, BAC and AMZN coming from parts industry, automobile manufacturing, education, banking and e-commerce, respectively. Their revised closing prices are used for analysis. After data cleaning, 252 data have been obtained before processing them into the form of return. The information is presented in the table 1.

Table 1. Value of statistics of the assets in the portfolio

	Mean	Volatility	Sharpe Ratio
PTAIY	1.63%	9.48%	17.19%
TSLA	1.75%	13.90%	12.60%
PSO	0.70%	9.17%	7.67%
BAC	-0.56%	6.70%	-8.30%
AMZN	-0.99%	9.81%	-10.12%

As can be seen in the table, the return of TSLA has the largest mean when AMZN has the smallest. Meanwhile, TSLA also has the largest volatility, almost twice as much as that of PSO. Largest Sharpe ratio can be seen in the returns of PTAIY, while AMZN has the smallest Sharpe ratio. It can be observed that the average return has a positive relationship with the Sharpe ratio. Daily returns of each asset in the portfolio are shown in the figure 1.

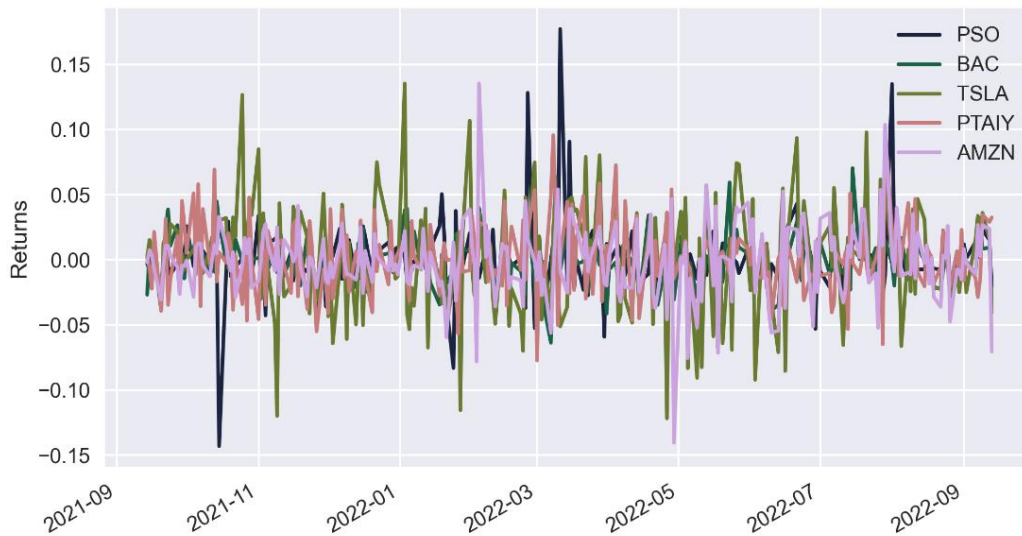


Figure 1. Daily returns of the considered assets

According to the figure above, the maximum value of daily return of PSO is the highest among the five assets in the portfolio, and the minimum value of daily return of PSO is the lowest among the five assets in the portfolio.

3. Method

3.1. Monte Carlo method

Monte Carlo simulation belongs to the field of computational math. It is widely used in probabilistic problems. It uses random numbers (or more commonly pseudorandom numbers) and performs multiple statistical simulations in a computer of the model built for the problem, which can approximate the solution of the problem. Monte Carlo simulation has a bunch of advantages, typically for intuitive visualization as well as its marvelous convenience in solving multi-dimension and multi-factor complexity problem without limitation. Therefore, it is also frequently used in financial research, where Bakar Nashirah Abu, for example, uses it to analyze the data volatility of Islamic finance stock prices [10].

In this problem, by using this method to carry out 100,000 Monte Carlo simulations, the effective frontier of portfolio can be drawn in Markowitz's portfolio theory. By finding the tangency portfolio on it, the portfolio with the maximum Sharpe ratio or minimum variance can be obtained.

3.2. Mean variance analysis

In the mean-variance model, the investor will decide the weight of each asset in his portfolio to get a better capital allocation method. Therefore, investors need to choose an optimal portfolio from all asset portfolios to meet the following two decision-making objectives: The portfolio should have the highest rate of return and the lowest uncertainty risk. Mean Variance analysis satisfies the following mathematical derivation.

$$\sigma^2 = \text{var} \left(\sum_i x_i r_i \right) = \sum_{ij} x_i x_j \text{cov}(r_i, r_j) \quad (1)$$

$$\sum_i x_i E(r_i) \geq \mu, \quad \sum_i x_i \leq 1 \quad (2)$$

Where x_i stands for the proportion of capital invested in assets i , the sum of investments $\sum_i x_i$ is no more than the budget. The expected return of r_i is $E(r_i)$, and the covariance of returns of the two stocks i and j is $\text{cov}(x_i, x_j)$. The expected return of the portfolio $\sum_i x_i E(r_i)$ is required exceeding

μ , which stands for the target expected return. In the process, Monte Carlo simulation method was considered to obtain the best portfolio.

3.3. Fama-French 3-factor model

According to the CAPM model, the excess return of one certain asset is a function of the market's irresolvable systematic risk, and it has nothing to do with unsystematic risk. However, the ability of β in CAPM model to explain portfolio returns is weak. Therefore, many scholars consider adding a series of indicators like some risk factors such as book-to-market ($\frac{BE}{ME}$) factor and inverse price-to-earnings ratio ($\frac{E}{P}$) to optimize the model, which greatly improve the explanatory power of the model.

On the basis of CAPM theory, Fama French model is proposed, which holds that the excess return of portfolio is relative to the market portfolio factor ($R_m - R_f$), the market value factor (SMB) and the book-to-market ratio factor (HML). Through the empirical analysis of scholars, Sanjay Sehgal and A. Balakrishnan for instance, FF3 model has a better effect than CAPM in explaining returns for the portfolio [11]. The expression for the model is as followed:

$$E(R_{it}) - R_{ft} = \alpha + \beta_i E(R_{mt} - R_{ft}) + s_i E(SMB_t) + h_i E(HMI_t) \quad (3)$$

The parameters of the model are under the background of time t, when $E(R_{mt} - R_{ft})$ stands for market risk premium, which is the expectation of market return (R_{mt}) minus risk-free return (R_{ft}), and R_{it} stands for the return rate of asset i . SMB_t and HMI_t respectively stands for the factor of market value as well as book-to-market in the simulation of portfolio return rate.

4. Results

After 100,000 Monte Carlo simulations, this paper have got the portfolio that forms the efficient frontier and obtained the portfolio with the largest Sharpe ratio as well as the Minimum Variance, which are displayed in the two graphs below, respectively (See Figures 2 and 3, respectively).

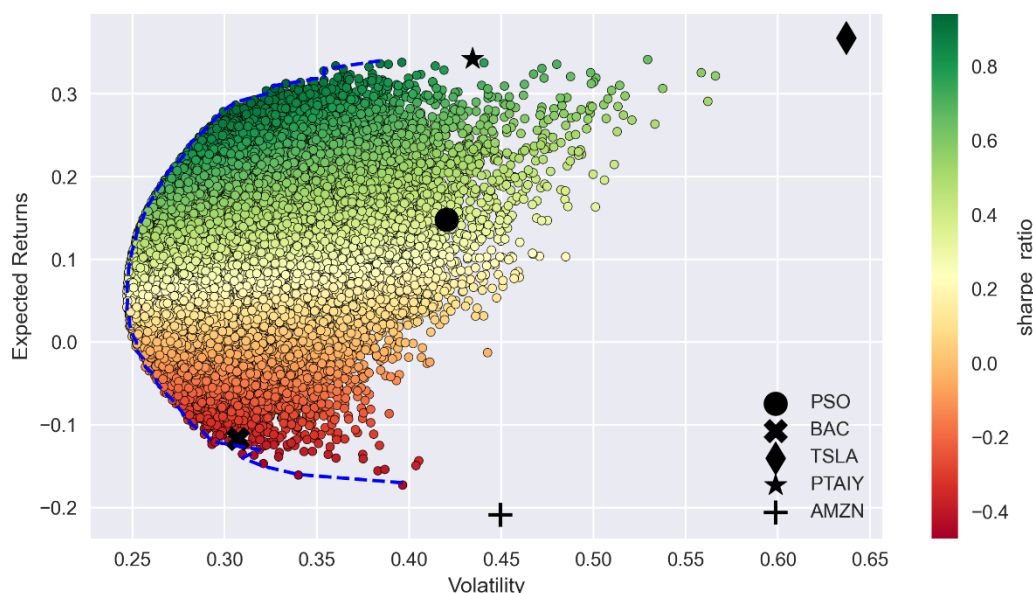


Figure 2. Efficient Frontier

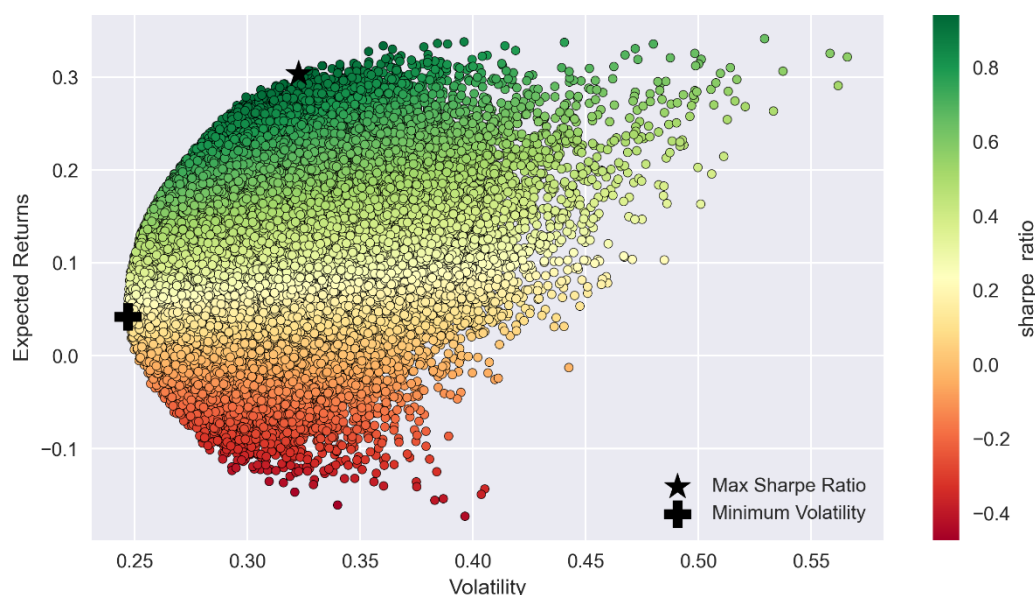


Figure 3. Maximum Sharpe Ratio portfolio and Minimum Variance portfolio

As can be seen from the figure, the portfolio of minimum variance as well as the maximum Sharpe ratio are located at the boundary of the efficient frontier. The minimum variance portfolio has lower volatility, while the maximum Sharpe ratio portfolio has higher volatility and expected return, and its performance position is in the upper right of the minimum variance portfolio.

Table 2. Weight and Performance of the Maximum Sharpe Ratio portfolio

	PSO	BAC	TSLA	PTAIY	AMZN
Weight	16.36%	2.05%	20.78%	60.33%	0.48%
Performance of the portfolio					
Returns					30.37%
Volatility					32.26%
Sharpe Ratio					94.14%

When considering the maximum Sharpe ratio portfolio, the table 2 shows that PTAIY occupies more than three-fifths of the weight, which is three times the share of TSLA. BAC and AMZN occupy less weight, and the sum of which is less than 3%, occupying 2.05% and 0.48% respectively.

The excellent performance of PTAIY may be attributed to the gradual recovery of the manufacturing industry under the background of the gradual decline of the global COVID-19 epidemic, the world has put forward higher requirements for industrial manufacturing, so that the society has paid more attention to the parts industry.

At the same time, it can be found that the optimized portfolio has a higher rate of return than the original assets under the mean-variance theory. Although volatility has also increased, the Sharpe ratio of the optimized portfolio is very high, almost five times more than the best performing PTAIY among the original assets.

Table 3. Weight and Performance of the Minimum Volatility portfolio

	PSO	BAC	TSLA	PTAIY	AMZN
Weight	22.60%	46.45%	0.80%	22.35%	7.80%
Performance of the portfolio					
Returns					4.23%
Volatility					24.70%
Sharpe Ratio					17.13%

When considering the minimum variance portfolio, BAC accounts for nearly half of the weight, the highest of the five assets in the portfolio. PSO and PTAIY occupy close to half the weight of BAC. TSLA and AMZN have less weight, with TSLA accounting for only 0.8% (See Table 3).

BAC occupies a large weight in the minimum variance portfolio. As the stock of Bank of America, it proves that its individual stocks are relatively excellent in volatility control. When considering reducing portfolio variance, bank stocks are a good choice in the asset allocation process.

For the optimized portfolio, this paper can find that although its return rate and Sharpe ratio are reduced, the volatility of the portfolio is also reduced, only reaching 24.70%, which is helpful for investors who want to significantly reduce the risk.

In a nutshell, comparing the weights of the assets in the two sample portfolios, the weight of PSO and AMZN changed slightly. While the weight of BAC increased dramatically, the weight of TSLA and PTAIY show a magnificent decline.

Table 4. Value of the factors in the Fama-French 3 factor model

	α	$R_{mkt} - R_f$	<i>SMB</i>	<i>HML</i>	<i>Info Ratio</i>
PSO	-8.386018	-0.002477	0.006078	0.000671	-92.075357
BAC	7.986269	-0.001820	0.000850	-0.002354	119.657337
TSLA	70.669656	0.000772	0.000378	-0.003612	509.308909
PTAIY	21.557174	0.004752	-0.004189	-0.003846	229.315050
AMZN	4.851691	-0.003570	-0.000931	-0.004959	49.740961

In this paper, Fama-French 3 factor model was used to assess assets in the portfolio, considering the sensitivity of various factors in the financial market, and the value of coefficients is shown in the table above 4. Alpha is excess return, and positive alpha is more sensitive to model specifications. Therefore, BAC, TSLA, PTAIY and AMZN have positive Alpha values, indicating good efficiency to portfolio construction.

If the $(R_{mkt} - R_f)$ coefficient that stands for Market risk premium is greater than 0, it indicates that the sample assets are running in the same trend as the overall market.

When the *SMB* coefficient is positive, it indicates that the sample portfolio is more inclined to allocate to small-cap stocks. Conversely, this means that large stock indexes will have higher returns. The *SMB* coefficients of PSO, BAC and TSLA are positive, while PTAIY and AMZN are negative, which explains the weight of the assets in the sample portfolio.

Considering the characteristics of the *HML* coefficients of BAC, TSLA, PTAIY, AMZN that are all less than 0, The negative value of *HML* coefficient indicates that the sample portfolio tend to allocate to growth stocks.

Finally, the information ratio was considered. Information ratio is an important index of portfolio management which is calculated by dividing the mean value of information coefficient by its standard deviation. It measures the benefits and risks of actively managed portfolios compared to the market. As seen in the table, BAC, TSLA and PTAIY perform well among the portfolios.

Furthermore, this paper considered using Fama-French 3 factor model to analyze the influence of portfolio under market factors, market value factors and book-to-market factors. The following is the analysis of the two sample portfolios.

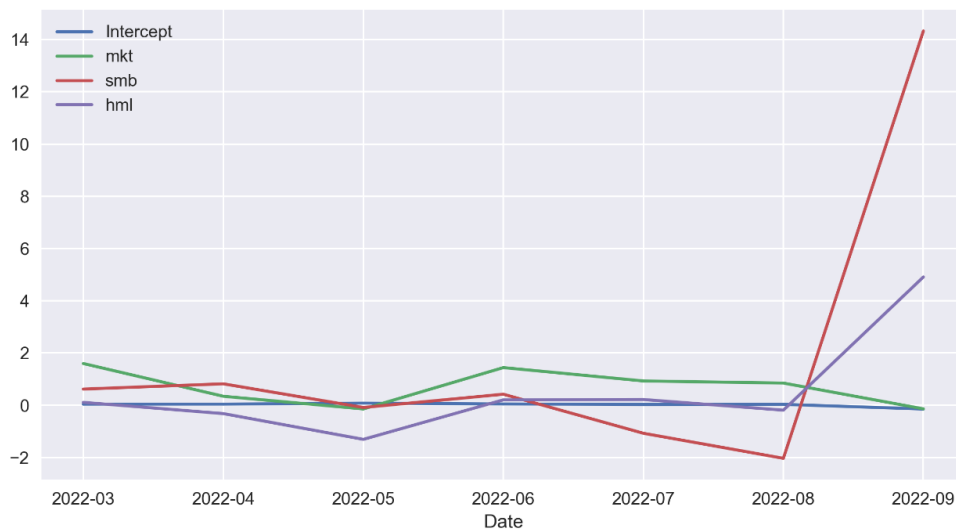


Figure 4. Rolling FF3 model for maximum sharpe ratio portfolio

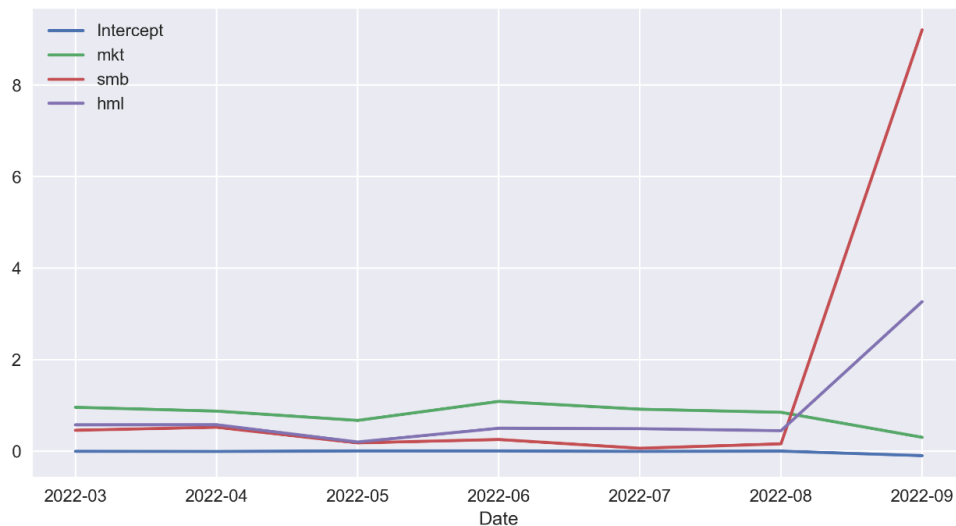


Figure 5. Rolling FF3 model for minimum variance portfolio

From the above two figures 4 and 5, this paper can see the impact of the three factors on the return of the two-sample portfolio. This paper can clearly observe that the maximum Sharpe ratio portfolio is more affected by financial markets than the minimum variance portfolio in most of time.

5. Conclusion

In the current portfolio research, most researchers focus on portfolio management in a specific industry or on the benefit analysis of the general financial market. The purpose of this article is to analyze portfolio management in several different industries, which is education, banking, automobile manufacturing, parts industry and e-commerce, respectively.

In this paper, Monte Carlo simulation is used to draw the effective frontier, and the mean-variance method is used to optimize the portfolio, and the two sample portfolios of maximum Sharpe ratio and the minimum variance are obtained. Research shows that the medical and PSO industries have a large weight in the above two investment portfolios, while banks and new energy occupy a large weight in the former and the latter, respectively. This paper uses Fama-French three factor model to analyze the two sample portfolios in three aspects: market factor, market value factor and book-to-market factor, and find that the maximum Sharpe ratio portfolio has higher sensitivity than the minimum volatility portfolio to the market.

There are some flaws in this article. Monte Carlo simulations have probabilistic errors. Meanwhile, the latest data of daily Fama-French three-factor model is only up to July 2022, so there is a problem of the acquisition time of the three factors.

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