Using Portfolio Theory to Balance Risk and Return

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Abstract. Investors prefer investing in different financial products in the capital market to earn higher returns—however, various financial products are changing constantly. Investors without relative information and tools can easily suffer some losses that can be easily avoided. So, the paper aims to provide a way for some investors to hedge risk and avoid nonsystematic risks. Based on Markowitz's portfolio theory, the paper will use the mean-variance model to show how to construct an optimal portfolio and check the portfolio by using the Sharp ratio. Baidu, Walmart, and Tesla stocks were selected as examples because these stocks have a negative correlation. Then, the paper will discuss how to decide each weight of stock by analyzing the past return of each stock and making an efficient portfolio. Lastly, the portfolio shows excellent results, showing the specific meaning of portfolio theory. It has a significant reference and practical application for investors to make better decisions when they choose financial assets in the capital market.

Keywords: portfolio theory, investment decision-making, risk, return, diversification.

1 Introduction

Investors will invest money into the capital market seeking higher returns, and they know the risk. The capital market needs cash from investors to operate normally and expand. With the rapid development of the financial industry, various financial instruments and products make investment choices, such as Exchange-Traded Funds (ETFs) and Peer-to-peer (P2P) [1].

One thing that has stayed the same is that investors always seek higher returns and lower risks. Everyone knows that the risks are equal to the return. So, most investors have a dilemma to manage risk and return. Investors are pleased to decrease risk but not willing to decrease return [2]. Hence, investing some money into bonds or fixed-income assets is only appropriate.

Furthermore, investors will suffer a higher risk if they invest too much equity. Portfolio theory is a popular and essential way to solve this dilemma. Diversification in portfolio theory involves investing money in different assets and fields to hedge risk [3]. For example, an investor can allocate more money into low-risk assets like bonds to reduce risk and allocate the rest into equity-like stock for higher returns. Investors could invest together in two industries, like gold and jewelry, to decrease risk. Most

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investors need to adjust the proportion of other assets for their risk tolerance, which can help them balance the risk and return.

The paper aims to discuss how to get the outcome of the balance. To get a convincing result, the paper will choose the shares of three listed companies to invest in. These companies are Baidu, Walmart and Tesla. They are all from different industries, which has negative correlations to hedge risk. The paper will illustrate how to use the three shares to invest by applying portfolio theory in reality. For the methodology, the paper will use Markowitz's portfolio theory to show how to invest.

Moreover, a programming solver will also be used to make optimal decisions. The solution can be an insight for some investors who need more investment tools or thoughts to do their portfolios. Hence, they can avoid suffering some underserved loss.

The paper aims to provide a valuable tool for investors to build a personal portfolio to diversify risk and get more profit. Besides, the paper can also supply a way of thinking for investors, such as how to tell a stock by themselves to reduce fraud. The structure of the paper is clear and easy, and it will introduce the content and limited conditions of portfolio theory. Moreover, it shows how to use linear programming to decide the weight of assets in the portfolio. Then, the portfolio theory, will decide how to invest in Baidu, Walmart and Tesla in proper proportions. In the end, the paper will calculate the Sharpe ratio of the portfolio and conclude.

2 Methodology

This article will use Markowitz's portfolio theory to analyze investment information to make an optimal portfolio. Markowitz's portfolio theory is also called the mean-variance model. In theory, the mean of return on assets can measure the expected return, and the variance of return on assets can assess the risk [4]. Harry Markowitz announced portfolio theory in 1952, which brought modern investment a new view. This theory believes combining more assets makes it easy to avoid unsystematic risk and achieve an equivalence of risk and return [5]. Portfolio theory has these assumed conditions:

Assume that all investors are risk-averse and make decisions based on rational consideration. When the returns on each asset are the same, investors prefer less risky investments.

Assume that the capital markets are perfect and efficient, having no restrictions on short selling or leverage. Moreover, there are no taxes or transaction costs in the capital market. Asset prices can reflect all available information and adjust rapidly for new situations.

Expected return and risk are essential for the part. The formula is the following.

$$\bar{r_i} = \frac{\sum_{i=1}^{n} \frac{p_n - p_{n-1}}{P_n}}{n} \tag{1}$$

$$\bar{r}_P = \sum_{i=1}^{n} w_i \bar{r}_i \tag{2}$$

$$\sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \cdot \sigma_{ij} \tag{3}$$

$$\sum_{i=1}^{n} w_i = 1 \tag{4}$$

For the formula (1), it is used to get the expected return of each company for each year; for formula (2), it is used to get the expected return of portfolio; for formula (3), it is used to get the variance of the portfolio; for the formula (4), it is a limitation which means the sum of weight of each company is one.

Where p stands for the price of the asset; $\bar{r}_P$ stands for the expected return of the portfolio; w_i , w_j stands for the weight of the asset i and asset j; $\bar{r}_i$ stands for the average return of asset i; σ_{ij} stands for the covariance between asset i and asset j; σ_p^2 stands for the variance of the portfolio.

When one investor decides to invest, it is not easy to decide the weight of each asset. Markowitz's portfolio theory does not clearly show how to ensure every asset's weight. But investors can assume the weight of each asset are w_1 ,w_2 , …… w_i , then calculate the expected return and variance of the portfolio and covariance matrix. This means that the value of expected return and risk are ensured, and the next step is to decide the weight of every asset. So, the investor needs to use a programming solver to solve weight when expected return and risk are constraints. Moreover, the linear programming method is the interior point method [6].

There is a crucial part of portfolio theory, and that part is the efficient frontier. An efficient frontier is the set of highest expected returns when the risk is lowest. The efficient frontier is often shown on a scatter plot in that the risk is on the x-axis, and the expected return is on the y-axis. With the help of an efficient frontier, the investor can search for more efficient assets and do their optimal portfolio [7]. An efficient frontier can be considered a convex function, mainly when the expected return and risk relationship is included. The interior point method is excellent for solving a convex optimization problem. This method can traverse the interior of the feasible region to get the optimal solution. Therefore, investors can get each asset's weight to make optimal portfolios.

The last part is the Sharpe ratio, a classical index to measure risk and return simultaneously. This is the formula.

$$SharpeRatio = \frac{E(R_P) - R_f}{\sigma_P} \tag{5}$$

Where $E(R_P)$ stands for the expected return of the portfolio, R_f stands for the interest of risk-free assets, σ_P Stands for the standard deviation of the portfolio [8].

3 Analysis and Discussion

The part will discuss how to use portfolio theory in reality. The paper will take three stocks: Baidu, Walmart, and Tesla. Their stock codes are BIDU, WMT and TSLA (in NYSE). Then, a portfolio based on the stock prices of the three companies will be made for ten years to achieve the best return for the lowest risk, where the stock prices are the closing prices on the last day of each quarter.

The first company is Baidu, one of the largest Internet companies in China, which primarily provides Internet search engine services like Google [9]. It was founded in 2000 in Beijing. Other online services, such as Baidu Maps and Baidu Wenku, are also available. Baidu has been operating well for ten years, and its annual revenue has generally increased.

Walmart is an excellent retail chain offering a wide range of goods and services in the United States. It was founded by Sam Walton in 1962 and has a long history and significant effect. Walmart also has many supermarkets worldwide and has become a retail giant. During the past ten years, Walmart's revenue has continuously increased.

Tesla is a company specializing in the development of electric cars. It is famous for its advanced technological innovation and is at the forefront of the world [10]. Tesla has many products like Model Y and Model 3. Moreover, Tesla has a new cybertruck, which will make a big wave in the auto industry. Tesla has been on a tear recently, and the revenue has exploded to $96,773 million US $ in 2023. These introductions show that the three companies made a considerable profit during the ten years and received the favor of shareholders.

According to historical data, these companies are from different industries, which can diversify the investment risk. Therefore, the three companies deserve to invest. In the following graph, the currency is USD, and the number under the stock code is the stock price. Firstly, the formula mentioned will be used to compute the Baidu return for each quarter. Then, it can get the average expected return, which can be considered the expected return. The expected returns for Tesla and Walmart are the same. The expected return of each company is in Table 1.

Table 1. The expected return of each company

Baidu	Walmart	Tesla
27.206%	2.711%	91.154%

Then, the formula is used to compute the variance of each company, and the results can be found in Table 2.

Table 2. Variance of each company

Baidu	Walmart	Tesla
0.0619	0.008	0.183

The covariance matrix of the three companies can be expressed in Table 3.

Table 3. covariance matrix of each company

	Baidu	Walmart	Tesla)
Baidu	0.061948673	-0.00263092	0.035005978
Walmart	-0.00263092	0.00806459	0.00223393
Tesla	0.035005978	0.00223393	0.182594515

Then the correlation is in Table 4.

Table 4. Correlation between three companies.

	Baidu	Tesla	Walmart
Baidu			
Walmart	-0.119		
Tesla	0.329	0.059	

The weight of each stock is unknown, but the weight of Baidu, Walmart, and Tesla can be assumed as 1,0,0. When this assumed weight is introduced into the calculation, it is easy to see that the expected return of the portfolio is 0.27206, and the variance of the portfolio is 0.061948673.

These data are assumed to be, and then the paper will use a programming solver to determine appropriate and specific proportions. Before programming, ensuring the programming target and setting limited conditions is essential. The programming target is to reduce the portfolio's risk, meaning to minimize the variance of the portfolio. There are two constraints set in the paper: one is that the sum of weight equals one, and the other is that the portfolio's expected return is not less than 0.27. WPS then simulated it to get the weight. The method is the interior point method. The weight can be found in Table 5.

Table 5. weight of each company

Baidu	Walmart	Tesla
0.13029671	0.631164337	0.238538953

The risk and return can be found in Table 6.

Table 6. Risk and return of the portfolio.

The expected return of portfolio	27.00%
Variance of portfolio	0.0171
Standard deviation	0.1307

For Sharp ratio, the US 10-year treasury note from 2024-02-15 to 2034-02-15 is used as a risk-free asset, and the return is 4.083% now, which means R_f Equals 0.04083. Based on the Sharp ratio formula, the sharp ratio is 1.75404522. The ratio tells investors they can get more than about 1.75% return when they suffer a 1% risk. Therefore, the portfolio performs well.

4 Conclusion

Though capital markets are in constant flux and become more complex, investing always pursues higher returns with lower risk. Portfolio theory is still of excellent use in the real world. On one hand, investors can use diversification strategies to manage risk. On the other hand, changing the proportion of portfolio can also help investors introduce more opportunities to earn more returns. The study aims to supply a comprehensive understanding of portfolio theory to help investors get knowledge and tools to do portfolios well. The methodology used in this paper involved a review of portfolio

theory and use cases in the real world to illustrate the actual application of portfolio theory. The real case is taking stocks of companies like Baidu, Walmart, and Tesla in this portfolio. The paper determines the optimal weight for each company within the portfolio to minimize the variance, which stands for the risk. At the same time, the expected portfolio return is equal to or greater than the minimum expectation set. The paper has already mentioned a range of assets in the capital market. Therefore, portfolios can be various and not just focused on stocks. Either a combination of ETFs and futures or a combination of funds is acceptable. Investors can even choose to invest in more than three assets. Diversified investment into different financial products so that different financial products can complement each other, which helps make an excellent portfolio.

The paper is based on past research and makes data changes and updates. Then, the paper will discuss the limitations and look forward. Firstly, the paper focuses on historical data from the three companies, which will cause some empirical problems and deviate from reality. So, the calculation result can be used to look back on the past and as a prediction reference. Besides, the range of data is ten years, which is too short and may cause some errors in the simulation. Secondly, there are many influence factors which do not consider. For example, investors will always seek high returns and overlook the high risk if they are not rational. At this time, portfolio theory will lose its meaning. In addition, the paper does not consider trading fees and commissions—the actual return may not be the same as the expected return. Capital markets are not always efficient, making the outcome unpredictable.

The paper shows a practical example using portfolio theory, which also has problems and inadequacies. The author hopes that the author or other researchers can take more profound and specific research in portfolio theory. Using more models and more extensive data to do better portfolio and optimize these limitations will help apply portfolio theory into realistic practice. Besides, the paper can inspire other researchers to push the development of portfolio theory.

Reference

1. Gomber, P., Kauffman, R. J., Parker, C., & Weber, B. W. (2018). On the fintech revolution: Interpreting the forces of innovation, disruption, and transformation in financial services. Journal of Management Information Systems, 35(1), 220-265.
2. Ainia, N. S. N., & Lutfi, L. (2019). The influence of risk perception, risk tolerance, overconfidence, and loss aversion towards investment decision making. Journal of Economics, Business, & Accountancy Ventura, 21(3), 401-413.
3. Koumou, G. B. (2020). Diversification and portfolio theory: a review. Financial Markets and Portfolio Management, 34(3), 267-312.
4. Zhai, J., & Bai, M. (2018). Mean-variance model for portfolio optimization with background risk based on uncertainty theory. International Journal of General Systems, 47(3), 294-312.
5. Sukrianingrum, D. R., & Manda, G. S. (2020). The effect of systematic risk and unsystematic risk on expected return of optimal portfolio. SAR (Soedirman Accounting Review): Journal of Accounting and Business, 5(2), 181-195.
6. Park, S., Song, H., & Lee, S. (2019). Linear programing models for portfolio optimization using a benchmark. The European Journal of Finance, 25(5), 435-457.

7. Qi, Y., Steuer, R. E., & Wimmer, M. (2017). An analytical derivation of the efficient surface in portfolio selection with three criteria. Annals of Operations Research, 251, 161-177.
8. Verma, M., & Hirpara, M. J. R. (2016). Performance evaluation of portfolio using the Sharpe, Jensen, and Treynor methods. Scholars Journal of Economics, Business and Management, 3(7), 382-390.
9. Shen, H. (2020). China's Tech Giants: Baidu, Alibaba, Tencent.
10. Alghalith, N. (2018). TESLA: INNOVATION WITH INFORMATION TECHNOLOGY. International Journal of Business Research & Information Technology (IJBRIT), 5(1).