Application of Modern Portfolio Theory in the New Energy Vehicle Industry

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Abstract: With the growing demand for sustainable development, the New Energy Vehicle Industry has grown vigorously, gradually becoming a new benchmark for investment in China. This paper attempts to construct an effective investment portfolio within the New Energy Vehicle Industry based on the Modern Portfolio Theory by using Python, which can effectively solve complex issues, such as computing the minimum variance portfolio and using Monte Carlo simulation. Through empirical research, it has been found that an investment portfolio comprising NAURA (002371), SMGJNY (600546), JCHITWINGT (002855), and the Camera Index (884876. WI) may yield higher returns, thereby achieving the practical application of Modern Portfolio Theory in the New Energy Vehicle Industry.

1. Theoretical Background

1.1 Modern Portfolio Theory

In 1952, Harry Horowitz's paper "Portfolio Selection" used probability theory and methods for solving quadratic programming to address the portfolio selection problem, marking the birth of modern asset portfolio management theory. Under the assumption that investors are risk-averse and seek to maximize expected returns, the Modern Portfolio Theory includes the Mean-Variance Model and the Efficient Frontier of Asset Portfolio.The theory suggests that the expected return on a portfolio can be quantified using the mean, while the investment risk can be assessed through the variance. Investment decision-making aims to find a portfolio with the minimum investment risk at the same or highest return at the same level of risk. Portfolios on the efficient frontier should satisfy both conditions.

1.1.1 Mean-Variance Model

Assuming an investor invests in a portfolio of several risky assets over a single investment period, where *ri* represents the expected return of the asset *i,* the expected return of the asset portfolio is:

$$E(\mathrm{r_p}) = \sum_{i=1}^{n} \mathrm{x_i} E(r_j) \tag{1}$$

where *xi* represents the investment weight of the asset *i*.

Using∂ to represent the variance of the asset *i,* the variance of the investment portfolio composed of numbers assets is:

$$\partial_{\mathrm{p}}^2 = \sum_{\mathrm{i=1}}^{\mathrm{n}} \sum_{\mathrm{j=1}}^{n} x_i x_j \operatorname{cov}(r_i, r_j) \tag{2}$$

where *i* and *j* represent different assets, and *cov(ri,rj)* is the covariance between assets *i* and *j*, a measure of the correlation between the returns of the two assets. The correlation coefficient between assets *i* and *j* can be used to compare the degree of correlation between two assets. Moreover, they represent the standard deviations of assets i and j, respectively.

According to formula (2), the risk of an investment portfolio mainly depends on each asset's

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investment weights, the correlation coefficients between different securities, and the standard deviations of each asset. Therefore, to reduce investment risk, we should prioritize selecting assets with more minor variances and lower correlation coefficients to construct the portfolio. In practical applications, sample averages and variances of past return data are often used to estimate future returns and risks.

1.1.2 Efficient Frontier of Asset Portfolio

All possible combinations of assets in the investment portfolio form a feasible set, similar to a left-convex area. A feasible set means a collection of all possible portfolios that can be formed from a given set of assets, reflecting various combinations of risk and return. The Minimum Variance Portfolios point marked represents the minimum variance asset portfolio, and the feasible set can be divided into two parts centered on this point. The portfolios on the upper half of the edge line meet the conditions of minimizing risk at a given level of return and maximizing returns at the same level of risk. They are referred to as the efficient frontier of the asset portfolio.

1.2 Sharpe Ratio

In 1966, William F. Sharpe introduced the Sharpe Ratio, which aimed to help investors understand the relationship between the risks and returns. A higher Sharpe Ratio indicates a better risk-adjusted return, meaning the investment has generated a higher return per unit of risk. Investors use the Sharpe Ratio to compare different investments or portfolios to determine which provides the best balance of risk and reward. It is calculated by subtracting the risk-free rate from the expected return of the investment and then dividing the result by the standard deviation of the investment's returns. The formula is as follows:

$$S_P = \frac{E(\mathrm{r_p}) - R_f}{\partial_P} \tag{3}$$

Where S_p represents the Sharpe Ratio of an asset portfolio, and R_f is the risk-free rate.

The Sharpe Ratio indicates how much excess return an asset portfolio can achieve for each additional unit of risk undertaken, comprehensively considering both returns and risks. The empirical research part of this paper will also use this indicator as a standard to judge the quality of individual investment targets and portfolios.

2. Literature Review

Since its inception by Harry Markowitz in 1952, the modern portfolio theory has become a significant theory in the field of financial investment. The theory emphasizes the importance of diversification and uses mathematical models to analyze and select assets, aiming to achieve the maximum expected return at a given level of risk or the minimum risk at a given level of expected return.

The development of Modern Portfolio Theory has significantly impacted investor behavior, changing how investors evaluate assets and financial markets. However, The Modern Portfolio Theory still has some limitations, which include assumptions about market efficiency and rational investor behavior, which only sometimes hold in real-world markets. Moreover, The Modern Portfolio Theory relies on historical data to estimate the risk and return of assets, but historical data may not accurately predict future market performance. Scholars have proposed some improvement strategies and alternative theories to address these limitations. For example, the Efficient Market Hypothesis suggests that in a stock market with sound legal systems, good functionality, high transparency, and entire competition, all valuable information is already timely, accurate, and fully reflected in the stock price trends, including companies' current and future value. Investors can only achieve excess profits above the market average with market manipulation by analyzing past prices. Behavioral Finance considers investors' psychological factors, such as overconfidence and herd behavior, which can affect investment decisions.

With the advancement of big data and cloud computing technologies, some researchers have

attempted to combine algorithms with Modern Portfolio Theory to propose new investment strategies and apply them to practice. For example, Sun Libo (2020), in his empirical research based on Python, selected five stocks from 20 different industries for analysis. The empirical research obtained the optimal portfolio with the maximum Sharpe Ratio and the minimum variance, compared and analyzed their expected returns, standard deviations, and Sharpe Ratios, and provided the efficient frontier of the asset portfolio[1].Chen Yuxin (2023) pointed out in his research that the goal of stock portfolio investment is to achieve the maximum return under the same risk conditions. By simulating the operation of a group of stock portfolios for return and risk analysis, it is verified whether the construction of the stock portfolio meets the investors' expectations[2]. Qi Qi's (2021) research took the monthly stock data of four listed companies from January 2010 to October 2019 as the research object, used the Modern Portfolio Theory as the research method, and planned the solution as the research means to find the feasible set and efficient frontier of the sample. The decision analysis process was explained through empirical analysis, showing that constructing the securities portfolio using Modern Portfolio Theory, mean-variance analysis, and Excel planning solution is feasible [3]. Alzaman Chaher (2024) mentioned in his research that investors need powerful algorithms to master and understand boisterous and volatile markets. The author used deep learning to select stock portfolios and genetic algorithms to optimize the hyper-parameters[4].

The literature review shows that the Modern Portfolio Theory is a powerful tool despite its limitations. It needs continuous development and improvement to adapt to the ever-changing financial markets and investment environment. As the number of securities in the portfolio increases, the portfolio's risk will decrease, which means that by investing in more securities, investors can avoid the specific risks involved in individual companies.

3. Research Content and Methods

With the rapid development of the New Energy Vehicle Industry in China, its position in the national economy has become increasingly significant. The development of the new energy vehicle industry is indispensable for promoting the upgrade of the automotive industry, enhancing international competitiveness, and providing an increasing array of opportunities for investors. The New Energy Vehicle Industry encompasses a broad spectrum of interconnected sectors and associated enterprises, ranging from raw material provisioning to manufacturing, distribution, sales, and post-purchase services. However, effectively constructing an investment portfolio in the New Energy Vehicle Industry to balance risk and return is still a problem that needs to be solved in the investment field.

The main problem studied in this paper is using Python to illustrate an application example of the Modern Portfolio Theory in selecting the optimal investment portfolio in the New Energy Vehicle Industry. Python has a complete set of data analysis tools and can access financial data such as stock prices through packages, providing great convenience for solving financial problems. Using Python to solve the optimal investment portfolio can effectively solve the complex calculation of covariance and correlation coefficients between various assets. Research shows that the optimal investment portfolio can be quickly calculated in Python, and new technology has essential value for the practical application of Modern Portfolio Theory.

4. Empirical Research

4.1 Sample Selection and Data Acquisition

This paper collects fifteen industries related to the New Energy Vehicle Industry from the Wind database. First, calculate the Sharpe Ratio of the automotive manufacturing industry, compare and filter out industries with lower Sharpe Ratios than the automotive manufacturing industry, and select industries with relatively high Sharpe Ratios. Secondly, the companies with the most significant market value in each industry should be selected to create an asset library. Finally, the correlation coefficients between each industry in the library are calculated, and according to the

correlation requirements, four to five companies are kept in the library for the combination. According to the above method, the Semiconductors Industries, Energy Industries, Consumer electronics Industries, and Camera Industries were selected, and four companies were screened, namely NAURA(NAURA Technology Group Co., Ltd), SMGJNY(Shanxi Coal International Energy Group Co., Ltd.), CHITWINGT (Dongguan Jierong Technology Co., Ltd). Among these, the Sharpe Ratios of the larger market value companies in the Camera Industry were all negative, so the Camera Index(884876.WI)was selected as one of the assets.

4.2 Data Selection and Prepossessing

The average return, annualized return, variance, standard deviation, annualized volatility, risk-free rate, and Sharpe Ratio of NAURA, SMGJNY , JCHITWINGT, and Camera Index were calculated through relevant functions. The primary purpose of this paper is to analyze the stock trend and construct an investment portfolio. More detailed data is needed, so the annualized daily average return is used. The relevant data for each asset is shown in Table 1.

Table 1. Relevant Data Table of Each Asset

Asset Subject	Average Return	Annualized Return	Variance	Standard Deviation	Annualized Volatility	Risk-free Rate	Sharpe Ratio
NAURA	0.0015	0.3740	0.0013	0.0356	0.5623	0.0293	0.6130
SMGJNY	0.0014	0.3521	0.0013	0.0361	0.5709	0.0293	0.5654
CHITWINGT	0.0012	0.3066	0.0011	0.0330	0.5221	0.0293	0.5311
Camera Index	0.0009	0.2133	0.0005	0.0214	0.3384	0.0293	0.5436

Correlation can be expressed through the correlation coefficient. When the correlation coefficient between two stocks is low, these two investment portfolios' variance and standard deviation are low, indicating a good diversification effect, and vice versa. We use Python for data processing and calculate the correlation coefficient matrix in Table 2.

Table 2. Asset Correlation Coefficient Matrix

Correlation Coefficient Matrix	NAURA	SMGJNY	CHITWINGT	Camera Index
NAURA	1	0.1222	0.1767	0.5754
SMGJNY	0.1222	1	0.1437	0.2497
CHITWINGT	0.1767	0.1437	1	0.4009
Camera Index	0.5754	0.2497	0.4009	1

Using Python to estimate the correlation coefficients between each other, Table 2 shows that the correlation coefficients between any two assets are relatively low. The correlation coefficients between certain assets,such as NAURA, JCHITWINGT, and Camera Index, are relatively large. It is preliminary concluded that an investment portfolio suitable for medium-risk investors can be constructed.

4.3 Monte Carlo Simulation to Find the Optimal Investment Portfolio

Monte Carlo simulation is a computational method based on random sampling, widely used in finance, engineering, scientific research, and other fields to evaluate the behavior of complex systems and predict future development trends. This method generates many possible results through random sampling, thereby helping to predict the possible outputs of a process. Unlike traditional forecasting models, Monte Carlo simulation does not base its predictions on fixed input values but rather on a range of possible values. It uses probability distributions, such as uniform or normal distributions, to build a model of possible outcomes. It recalculates the results repeatedly using different random numbers, producing many likely outcomes.

This paper chose the above four listed assets for Monte Carlo simulation to prove this research hypothesis. To obtain the optimal investment portfolio and use the optimal investment portfolio to obtain the maximum investment return, we conducted 10,000-100,000 Monte Carlo simulations, and the output results remained unchanged, so this paper believes that this result has tended to the

global optimal solution.

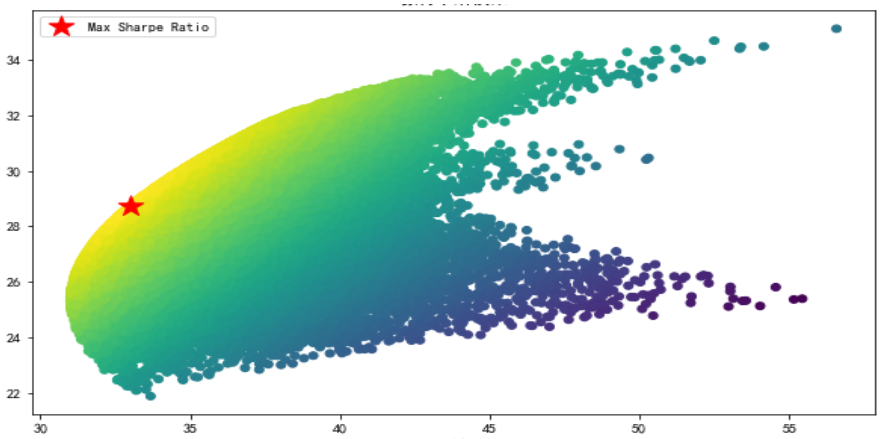

Figure.1 Portfolio Efficient Frontier

As shown in Figure 1, the efficient frontier depicts the optimal relationship between return and risk in different combinations. The red star represents the optimal combination on the frontier, representing the maximum return for a given level of risk or the minimum risk for a given level of return. In other words, an approximate global optimal combination was found through simulation.

As shown in Table 3,the Sharpe Ratio of the investment portfolio can reach a maximum of 0.8697. The investment portfolio with the maximum Sharpe Ratio should be chosen for rational investors. The investment weights for NAURA, SMGJNY, JCHITWINGT , and Camera Index are 11.09%, 31.40%, 28.04%, and 29.48%, respectively, and the expected return of this investment portfolio is 28.75%. The optimal investment portfolio is higher than any single company and index, and investors can obtain higher returns according to the investment weights of the optimal investment portfolio.

According to Table 3, the performance of investment portfolio surpasses any single stock or index. Rational Investors can achieve higher returns by following the investment weights of the optimal portfolio.

Table 3.Optimal Investment Portfolio Table

Portfolio Assets	NAURA	SMGJNY	CHITWINGT	Camera Index
Portfolio Expected Return		28.7514		
portfolio volatility		33.0238		
Portfolio Sharpe Ratio		0.8697		
Optimal Portfolio Weights	0.1109	0.3140	0.2804	0.2948

5. Conclusion and Suggestions

5.1 Research Results

The research indicates that investors can utilize Python to construct various asset portfolios with the minimum risk or the highest Sharpe Ratio, thereby applying Modern Portfolio Theory in securities investment. When market conditions are favorable, an investment portfolio composed of NAURA, SMGJNY, JCHITWINGT, and Camera Index in the New Energy Vehicle Industry may bring higher returns. The above asset combination is beautiful for investors willing to bear higher risks to pursue substantial returns. Investors should invest rationally according to their actual ability and risk preference.

5.2 Suggestions

Rational investors usually hope to find a balance between risk and return, expecting to obtain returns higher than low-risk investments, but want to avoid the potential losses of high-risk investments. Therefore, it is essential to establish a diversified investment portfolio to ensure that relatively high returns are achieved while controlling risks. Here are some suggestions: 1)

Diversified Investment: Construct an investment portfolio covering a variety of assets such as stocks, bonds, real estate, and commodities to achieve adequate risk diversification. 2) Balance the Investment Portfolio: Regularly review and re-balance the portfolio to ensure it is consistent with personal risk preferences and investment objectives. Market fluctuations may cause some assets' proportions to deviate, and appropriate adjustments are necessary. 3) Long-term Perspective: Maintain a long-term investment perspective and do not make blind decisions due to short-term market fluctuations.

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