Research on the Optimal Portfolio of New Energy Industry Based on Markowitz Model

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Abstract. Based on Markowitz's portfolio theory, the risks and returns of stocks can be obtained from calculating the historical data, ensuring effective returns with low risk by decentralized investment, which has a considerable degree of practical significance to China's public investment under the current situation. In recent years, the total market capitalization of the new energy industry and the attainable gains from it are growing rapidly, in which case investors need to analyze and evaluate the volatility to determine how to invest. This paper extracts the historical closing price of new energy automobile related industry 7 stocks from June 2018 to March 2024 through the SuperMind database and establishes the mean-variance model, showing the optimal portfolio of new energy industry in the market with short-selling and the market without short-selling and giving a practical investment proposal on weights allocation.

Keywords: Optimal portfolio; new energy industry; Markowitz model.

1. Introduction

As a technical analysis model, Markowitz model can provide scientific analysis of stock investment for the public on the basis of basic financial knowledge [1]. Zeng et al. took several stocks in China's market as samples to conduct empirical analysis and indicated the effectiveness, “Because the effective combination is better than the basic securities in nature, it shows that Markowitz portfolio theory has a certain role in China's stock market. It is found that the risk of the Markowitz effective portfolio at the same level of expected return is much lower than the underlying securities, indicating that the Markowitz effective portfolio is qualitatively superior to the underlying securities.” [2]. Wang et al. proposed more sensible recommendations for the distribution of household assets by using the Markowitz portfolio model to analyze the proportionate allocation of risky and risk-free assets [3]. Wu thinks that although the Markowitz portfolio approach has inherent drawbacks, it can nevertheless be useful in the A-shares market. By removing low-yielding but high-risk assets from the market, portfolio investing helps to lower total investment risk. However, there will be very little chance of using the model to guide investment decisions if its creation is predicated on the three predetermined criteria of an idealized investor base, no transaction costs, and an effective market [4]. Li et al. indicated that although the Markowitz model has defects to a certain extent, it can be appropriately modified according to the actual situation and can also be applied to China's securities market [5].

The new energy vehicle industry is an industry that can attract investors’ capital in China recently. The Ministry of Industry and Information Technology reported that in 2023, in 2023, 9.5 million new energy vehicles will be sold in China, accounting for 31.6% of the market. The production and sales volume of new energy vehicles ranked first in the world for nine consecutive years, accounting for more than 60% of the world [6]. China's new energy vehicle industry policies have played an important role in the industry's development by introducing a series of policy measures such as subsidies for new energy vehicle purchases and exemption from purchase taxes, as well as incentives for charging infrastructure construction [7]. In addition to lowering vehicle exhaust pollutants, easing the impact of oil shortages, fostering the modernization and transformation of the auto industry, and guaranteeing the transportation sector's sustainable growth, new energy vehicles are essential [8].

The main purpose of this paper is to provide investors with analysis of the optimal portfolio and efficiency frontier of the stocks of companies in the key parts of the market within the full industry chain of the new energy sector for reference.

2. Data and Method

2.1. Markowitz Model

Markowitz's portfolio theory was first developed in 1952. The mean-variance model proposed by him is to find the efficient frontier of the investment portfolio based on the mean and variance of the returns of individual stocks in the portfolio under the assumption of banning short selling and no risk-free lending, that is, the portfolio with the minimum variance under a certain level of returns, and derive that investors can only choose the portfolio on the efficient boundary. According to the concept of Markowitz portfolio, if you want to minimize the risk of your portfolio, you should choose stocks with low correlation coefficient in addition to diversifying into different stocks. For the first time, the relationship between risk and the rate of return on hazardous assets is being used to explore how to choose the best asset portfolio inside the economic system. The foundation of contemporary investment theory is the portfolio selection model, which is extensively applied in the financial sector of industrialized nations and regions. It also centers portfolio investment on risk diversification. It is used to calculate, objectively, the optimal investment portfolio that supports the development of sound investment concepts and the stability of the financial system. The Markowitz mean-variance model offers a technical route to identifying the efficiency frontier while simultaneously functioning as a normative mathematical paradigm.

The assumptions of the Markowitz model include,

1) Based on the probability distribution of security returns over a specific holding time, investors evaluate each investment option.

2) Based on the expected return rate of a security, Investors estimate the risk of a portfolio.

3) The risk and return of the security are the only factors that influence the investor's choice.

4) At a certain risk level, investors expect the maximum return; the corresponding is that investors want to minimize risk at a certain level of return.

The aforementioned theory states that Markowitz developed the efficient frontier theory, the means of calculating portfolio risk and expected return, and the mean-variance model of ideal asset allocation:

Objective function:

$$min\sigma^2(r_p) = \sum\sum \omega_i\, \omega_j Cov(r_i, r_j) \tag{1}$$

$$E(r_p) = \sum \omega_i\, r_p \tag{2}$$

Constraints in the two condition:

$$\begin{cases} \sum \omega_i = 1, \quad \omega_i \geq 0\ (sell\ short\ is\ not\ allowed) \\ \sum \omega_i = 1\ (sell\ short\ is\ allowed) \end{cases} \tag{3}$$

In the function, σ^2represents the variance, r_i represents the return of stock i, ω_i represents the weight of stock i, E represents the expected return, $Cov(r_i, r_j)$ represents the covariance of stock i and stock j

2.2. Data

As shown in table 1, this paper selects 7 representative stocks in the new energy industry and related industries listed in Shanghai Stock Exchange and Shenzhen Stock Exchange for portfolio extraction of the closing price data at the end of each month from June 2018 to March 2024. During the period, China's securities market has continued to rise, but also has a sustained downturn. Therefore, it is of great typical significance to carry out empirical research in this interval [2]. The

sample includes 2 automobile companies (BYD, CHANGAN), 2 Lithium battery companies (SAIC, EVE Energy), 1 car-parts company (INOVANCE), 2 electric power companies (GD POWER, CHUANTOU Energy). Table 1 shows them with their stock code. For convenience, they will show in numbers (1 to 7) in the paper.

Table 1: Sample.

Company	Stock Code	Company	Stock Code
SSEC	000001.SH	SAIC	600104.SH
BYD	002594.SZ	EVE Energy (EVE)	300014.SZ
GD POWER (GD)	600795.SH	INOVANCE (INO)	300124.SZ
CHANGAN (CA)	000625.SZ	CHUANTOU Energy (CTE)	600674.SH

This paper selects the Shanghai Securities Composite Index (SSEC) as the market return(r_m), and the 10-year government bond as the risk-free rate. The data is collected from SuperMind and Ministry of Finance of the People's Republic of China.

3. Results and Discussion

3.1. Calculation of Parameters

$$r_i(t) = \alpha_i + \beta_i r_m + \varepsilon_i \quad (4)$$

Formula (4), the Security characteristic line of stock i, describes the linear relationship between the excess return of stock i and changes in macroeconomic conditions.

As mentioned previously, the risk-free rate is represented by 10-year government bond, with an annualized average return at 2.84%. The excess return is equal to the nominal return minus the risk-free rate. Based on it, the annualized average return is calculated from the monthly closing price. As shown in table 2, the other parameters needed in formula (4) are calculated with historical data. The company 4 (SAIC) has the highest return at 44.75% with a standard deviation at 62.2%. SSEC has a return at 0.96% with a standard deviation at 15.50%, illustrating that the overall performance of the stock market during this period is slightly depressed.

Table 2: Parameters.

	Annualized Average Return	Annualized Standard Deviation	beta	alpha	residual	Residual Standard Deviation
SSEC	0.96%	15.50%	1.000	0.000	0.00%	0.00%
BYD	34.48%	47.12%	0.993	0.335	33.52%	44.53%
GD	14.07%	29.28%	0.652	0.134	13.45%	27.49%
CA	24.76%	57.46%	1.853	0.230	9.94%	49.77%
SAIC	44.75%	62.20%	0.639	0.441	22.97%	61.41%
EVE	25.52%	50.75%	1.344	0.242	44.14%	46.28%
INO	17.56%	37.00%	1.413	0.162	16.43%	29.82%
CTE	12.58%	22.80%	0.432	0.122	27.59%	21.80%

The volatility of the Lithium battery industry is the highest, followed by the automobile industry. In the contrast, that of the electric power industry is the lowest, due to their nature of infrastructure.

As shown in table 3, it illustrates how the statistical index of the strong correlation between stocks or between stocks and SSEC is reflected in the correlation coefficient. The variation between stock portfolios, or the risk diversification of stock portfolios, is influenced by the correlation coefficient. The variance or standard deviation of the portfolio investment decreases with decreasing correlation coefficients between stock pairs, suggesting a larger effect of investment diversification, and vice versa. The qualitative study of the correlation between the two equities is further illustrated by the correlation coefficient's sign.

Table 3: Correlation Coefficients.

	SSEC	BYD	GD	CA	SAIC	EVE	INO	CTE
SSEC	1	0.33	0.34	0.50	0.16	0.41	0.59	0.29
BYD	0.33	1	-0.02	0.39	0.37	0.42	0.29	-0.01
GD	0.34	-0.02	1	0.11	-0.13	-0.02	0.13	0.62
CA	0.50	0.39	0.11	1	0.15	0.29	0.37	0.05
SAIC	0.16	0.37	-0.13	0.15	1	0.35	0.32	-0.17
EVE	0.41	0.42	-0.02	0.29	0.35	1	0.44	-0.11
INO	0.59	0.29	0.13	0.37	0.32	0.44	1	-0.04
CTE	0.29	-0.01	0.62	0.05	-0.17	-0.11	-0.04	1

As shown in table 3, the correlation coefficient between each two stocks is less than 1 and is close to 0, which shows that the correlation of 4 stocks is very weak and the probability that all stocks fall at the same time is smaller. Therefore, investing in these four stocks at the same time can help investors effectively spread their risk [9]. Furthermore, we could find apparently that the correlation between the car-parts industry and the overall market is the greatest.

3.2. Construction of the optimal portfolio

The above data are substituted into the formula (1) (2) (3), receiving the weights of each stock and the return and risk of the portfolios in different conditions. The calculation is done by solver.

Table 4: Optimal Portfolio.

	SSEC	BYD	GD	CA	SAIC	EVE	INO	CTE
SSEC	1	0.33	0.34	0.50	0.16	0.41	0.59	0.29
BYD	0.33	1	-0.02	0.39	0.37	0.42	0.29	-0.01
GD	0.34	-0.02	1	0.11	-0.13	-0.02	0.13	0.62
CA	0.50	0.39	0.11	1	0.15	0.29	0.37	0.05
SAIC	0.16	0.37	-0.13	0.15	1	0.35	0.32	-0.17
EVE	0.41	0.42	-0.02	0.29	0.35	1	0.44	-0.11
INO	0.59	0.29	0.13	0.37	0.32	0.44	1	-0.04
CTE	0.29	-0.01	0.62	0.05	-0.17	-0.11	-0.04	1

As shown in table 4, in the market without short-selling, the portfolio with the minimum variance has a return at 5.862%, a standard deviation at 14.152% and a Sharpe ratio at 0.414, while the weights of stocks are SSEC (69.24%), SAIC (4.12%), CTE (26.64%) and others are zero. The portfolio with the maximum Sharpe ratio has a return at 23.026%, a standard deviation at 20.423% and a Sharpe ratio at 1.127, while the weights of stocks are BYD (16.09%), GD (13.70%), CA (1.94%), SAIC (17.83%), EVE (4.42%), INO (3.57%), CTE (42.46%). The figures for the condition which is in the market with short-selling are also shown in table 4. Because of the restrictions of Chinese A- shares for short-selling, the figures received in another case are more valuable for reference.

3.3. The efficiency frontier

Set the expected yield and variance of 7 stocks and SSEC into the portfolio optimization problem, and limit the proportion sum of all assets to 1 to optimize the portfolio [9].

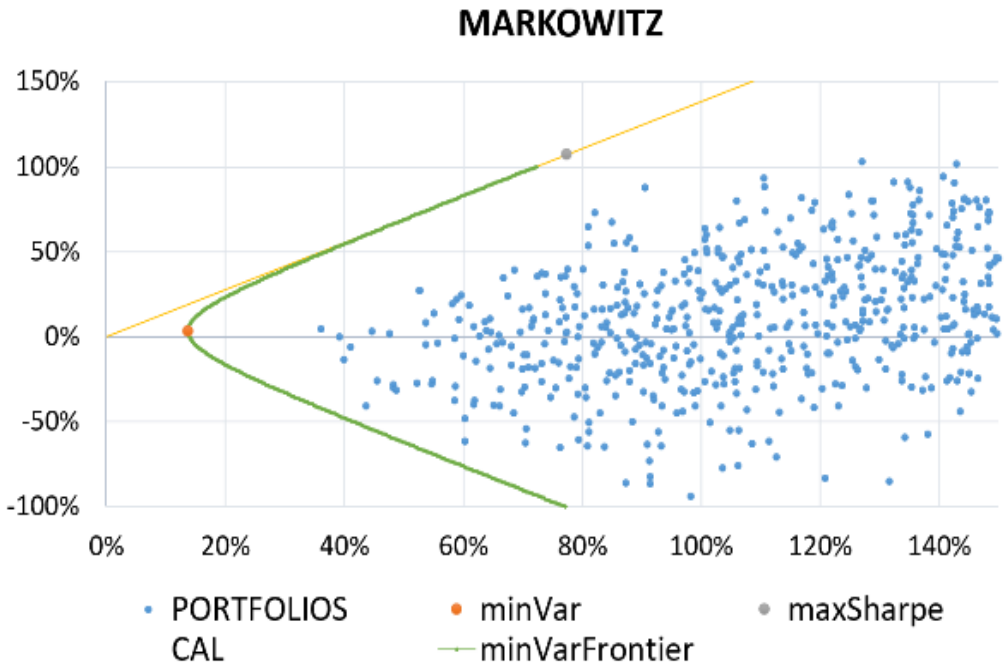

Figure 1: The efficiency frontier in the condition with short-selling

As shown in figure 1, the blue points are portfolios with random weights. None of them exceed the efficiency frontier. The optimal portfolios shown in Table 4 are also marked in the chart. The yellow line is the capital allocation line (CAL), starting from origin through the point with maximum Sharpe ratio. We use the excess return to analysis them, so the CAL has no intercept.

As shown in figure 1, any point on the curve denotes a possible portfolio, the ordinate denotes return, and the abscissa denotes risk. The matching two points on the ordinate and horizontal can be used to calculate the risk and return combination that each portfolio security offers.

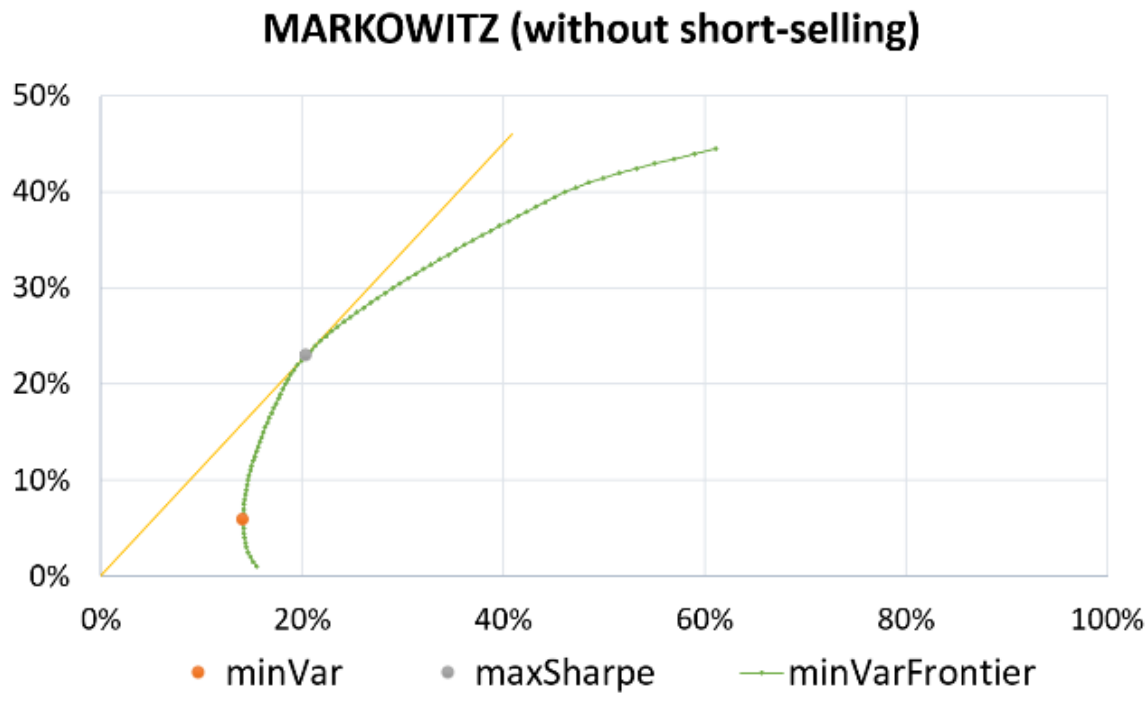

Figure 2: The efficiency frontier in the condition without short-selling.

As shown in figure 2, for seeing clearly, the two charts are drawn with different axis scale, but actually the slope of CAL in Chart 1 is bigger than that of CAL in Chart 2. This can also be known from observing the Table 4.

4. Conclusion

In this paper, we predict the future volatility of the new energy vehicle industry by constructing the Markowitz model. The research results show that the new energy vehicle industry has a high investment risk in the future, but it also has a huge profit potential. Therefore, investors should fully consider the characteristics of each link of the industrial chain in order to realize the balance between income and risk.

First of all, we believe that the new energy vehicle industry will show high volatility in the future. This is because the new energy vehicle industry is in the stage of rapid development, all kinds of technological innovation, policy adjustment, market competition and other factors may have a greater impact on it. In this case, investors need to have an in-depth understanding of each link of the industry chain, in order to better grasp the investment opportunities.

Furthermore, we suggest that investors in the new energy vehicle industry, mainly allocate funds to the power industry. This is because the electric power industry, as the foundation of the new energy vehicle industry, its development momentum is closely related to the new energy vehicles. By investing in the power industry, investors can enjoy the dividend of the upward development of the new energy vehicle industry and reduce the volatility of the investment portfolio. In addition, clean energy, smart grid and other fields in the power industry are also quality targets that investors cannot ignore.

In addition, for investors with strong risk tolerance, the funds can be mainly allocated in the lithium battery industry. As the core component of new energy vehicles, its technological innovation and cost reduction will have a profound impact on the whole industrial chain. Investing in the lithium battery industry is expected to yield higher expected returns. However, investors also need to pay attention to the risks of the lithium battery industry, such as technological change, policy adjustment and other factors may have an uncertain impact on the industry.

In short, through the construction of Markowitz model, we have provided certain investment guidance for investors in the new energy vehicle industry. In the future investment practice, investors need to use these suggestions flexibly according to their own situation to achieve the stability and growth of investment income. At the same time, the government and enterprises should also continue to increase policy support and investment in the new energy vehicle industry, promote the sustainable development of the industry, and create more value for investors.

Because of the impact of COVID-19 on the stock market from 2020 to 2022, there has been a certain increase in the volatility of the market, so the standard deviations in the model are over estimated. We should be optimistic about the volatility in the future.

There are some limitations in this paper.

Firstly, some companies who have a large market capitalization with a negative average return haven’t been selected in to the sample, such as Shanghai Automotive Industry Corporation, so the conclusion can’t be applied on the whole market.

Secondly, the problem of market efficiency. As to American finance Professor Eugene Fama's efficient market hypothesis. A market may only be considered efficient when its stock price accurately and promptly reflects all available information. Because the market itself may fail, a fully efficient stock market is an ideal realm. The real stock market has a high prevalence of insider trading, non-random fluctuations in stock prices, and a weak relationship between price movements and financial gains for corporations.

Thirdly, transaction cost problem. The transaction cost is not taken into consideration while constructing the Markowitz model. Securities that ignore transaction costs in the portfolio investment process will lead to non-efficient portfolio investment.

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