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The Research on the Investment Portfolio of New Energy Sector Based on Markowitz Model and the Index Model

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Abstract: New energy sector stocks in the Chinese market continue to grow at a high rate for two years in 2020 and 2021, but start to retrace in 2022. In order to investigate whether the new energy sector is still worth investing in and to find the optimal portfolio for the new energy industry, this paper analyzes fifteen stocks in the new energy sector using the Markowitz model and the index model. The following conclusions are drawn: 1. Under the constraint that shorting is not allowed in China's stock market, the index model is still advantageous. 2.Investors are more inclined to invest in the Shanghai Composite Index when seeking minimum risk. 3. Under the condition of maximum Sharpe ratio, investors are more willing to invest in the BYD Company Limited, Contemporary Amperex Technology, and EVE Energy. There are many methods of portfolio model construction at this stage, but this paper only analyzes only the Markowitz model and the index model in depth. In the future, other models can be compared and analyzed in depth to get the most suitable portfolio model for the new energy industry.

Keywords: New energy sector, Optimal portfolio, Markowitz Model, Index Model, Sharp Ratio

1. Introduction

Energy has multiple roles in modern society, with important implications for the economy, livelihoods, the environment and national security. The choice of energy sources and the way they are used have a direct impact on the environment. The utilization of conventional fossil energy sources such as coal, oil, and natural gas results in substantial carbon emissions and air pollutants, significantly affecting the environment. Conversely, renewable energy sources like wind and solar power exhibit reduced carbon emissions and environmental footprints, helping to reduce environmental pollution and climate change. Therefore, rational utilization of energy, promotion of energy transition and improvement of energy utilization efficiency are important topics for the development of today's society.

Indeed, climate change is a universal challenge that affects everyone on the planet [1]. China's announcement of the "carbon peaking and carbon neutrality" goal in 2020 demonstrates its commitment to fostering a fair, equitable, and mutually beneficial global climate governance framework. This initiative aims to achieve peak carbon emissions by 2030 and carbon neutrality by 2060, reflecting China's proactive approach towards addressing climate change on a global scale [2]. China is also taking action to achieve this goal, for example, by gradually shifting to cleaner energy

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sources to reduce its dependence on high-carbon energy sources such as coal, and the Chinese government is also pushing industries to improve energy efficiency to reduce carbon emissions. The release of such policies resulted in stocks in the new energy sector realizing substantial growth in 2020-2021, and after two consecutive years of significant gains in 2020 and 2021, the new energy sector began to pull back from the end of 2021. One of the representative indices, the CSI New Energy Index, as of February 18, 2022, has fallen a total of over 13% since 22. However, in recent years, wind power, photovoltaic as the representative of the new energy industry to realize the vigorous development, to promote the energy transition has injected a strong kinetic energy. The success of China's new energy industry in 2023, with its installed capacity surpassing that of thermal power for the first time, is indeed remarkable. This achievement not only indicates significant progress in the field but also serves as a source of encouragement and confidence for those involved in the new energy sector [3]. Zhang Zhiwu, Party Secretary and Chairman of China Guangnuclear New Energy Holding Co., Ltd. believes that the new energy industry is booming, and under the strong impetus of the "double carbon" target, China's new energy industry with wind power as the mainstay will enter an accelerated stage of development [3].

In order to explore whether the new energy industry still has investment value as well as investment weighting, this paper uses the Markowitz model and the index model to construct portfolios of stocks in the new energy sector and find the optimal portfolio solution. Wu and Zhao argue that using the Markowitz portfolio model, investors can calculate an effective portfolio plan when the return and covariance matrices of each stock in the stock portfolio are known [4]. Chen highlights the theoretical constraints inherent in the Markowitz model [5]. In other words, the Chinese stock market's present performance falls short of the intended outcome due to varying risk preferences among individual investors and systematic factors inherent to the stock market [5]. Therefore, it should be combined with their own actual situation rational investment. However, Josmy Varghese and Anoop Joseph thought Markowitz introduced the mean-variance model almost six decades ago, and its enduring popularity suggests it will likely remain relevant for the foreseeable future [6].

The advantage of the single index model is that on the one hand, it reduces the computational burden, and on the other hand, it also introduces the concept of common factors, which provides a brand new perspective for the scientific and objective in-depth study of systematic and idiosyncratic risks of the securities portfolio. Liu shows the efficiency of the single index model in the securities market, on the one hand, the model is simple and suitable for general investors to get started easily; on the other hand, it is able to accurately identify the optimal portfolio while controlling the effective boundaries of risky asset portfolios [7]. Liang pointed out that although the optimal risk portfolio constructed by the single-index model can obtain excess returns over the broad market index. However, market friction exists in actual trading and cannot be ignored. Therefore, it is necessary to consider the transaction costs and other factors into the model in the actual application [8].

Lin set different constraints on portfolio weights and found that both models present similar results, no matter under which constraint [9]. Aisha Hanif, Nur Ravita Hanun, Rizki Eka Febriansah studied the LQ 45 Index the era of the COVID 19 pandemic by using Markowitz Model and found which stocks can form an optimal portfolio [10]. Tri Yuwono and Dadan Ramdhani used the Markowitz model and Index Model for offering a better choice in selecting the optimal portfolio of stocks listed on the Jakarta Islamic Index in Indonesia Stock Exchange [11].

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2. Data and Method

2.1. Data

This study makes use of the prices of fifteen equities from the new energy industry that were traded from early June 2018 to early April 2024. In two models, the risk-free rate return and market index are represented by the interest rate of ten-year Treasury bond bonds and Shanghai Composite Index, respectively. The table 1 contains specific information.

Table 1: Specific information of fifteen stocks.

No	Code	Issuer Names
1	002594	BYD Company Limited
2	300750	Contemporary Amperex Technology Co., Ltd.
3	300014	EVE Energy Co., Ltd
4	300450	Wuxi Lead Intelligent Equipment CO.,LTD.
5	300124	Shenzhen Inovance Technology Co., Ltd
6	002709	Guangzhou Tinci Materials Technology Co., Ltd.
7	002460	Ganfeng Lithium Group Co., Ltd.
8	002340	GEM Co.,Ltd
9	603799	ZHEJIANG HUAYOU COBALT CO., LTD
10	002050	Zhejiang Sanhua Intelligent Controls Co.,Ltd.
11	002812	Yunnan Energy New Material Co., Ltd.
12	002074	Gotion High-tech Co.,Ltd.
13	300001	Qingdao TGOOD Electric Co., Ltd.
14	300037	Shenzhen Capchem Technology Co., Ltd
15	300207	Sunwoda Electronic Co.,Ltd.

Data were selected from the website of https://cn.investing.com for stock closing prices at the close of each day. To reduce the impact of non-Gaussian effects, this article transforms the collected daily data into monthly data for analysis.

2.2. Method

2.2.1. Markowitz Model

The Markowitz model, introduced by economist Harry Markowitz in 1952, is alternatively referred to as the mean-variance analysis framework or modern portfolio theory. This model is one of the foundations of capital market theory and is important for portfolio theory and practice.

The main goal of the Markowitz model is to maximize expected return for a given level of risk while diversifying over a range of assets to lower the total risk of the portfolio. The model specifically contains some following essential components and presumptions:

Statistical analysis of asset returns: The model assumes that the investor is able to accurately estimate the anticipated yield, variance, and co-variance of the asset, and that these returns conform to a normal distribution.

Balance between risk and reward: Investors consider not only expected return but also risk when constructing a portfolio. The Markowitz model balances risk and return by minimizing the variance (or standard deviation) at a given level of return.

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Efficient Boundary: The efficient frontier is a curve depicting the highest anticipated return achievable for a specified level of risk. The objective of the model is to select the best portfolio at the efficient frontier.

Risk-free asset: The model assumes that there is a riskless asset. and that investors can trade off that asset against risky assets to form portfolios with different levels of risk.

Correlation between assets: The model takes into account the covariance between different assets to reflect the correlation between them. By diversifying between different assets, the overall portfolio risk can be reduced.

In the Markowitz Model, the mean is determined by

$$E(r_P) = \Sigma\omega_i \tag{1}$$

In this case, ω_i represents the stock's weight, and γ_i is the return to the stock.

The variance is determined by

$$min\sigma^2(r_p) = \Sigma\Sigma\omega_i\omega_j cov(r_i r_j) \tag{2}$$

2.2.2. Index Model

Index Model is a methodology used to assess the performance and risk of asset portfolios. Such models assess the anticipated yield and risk of a portfolio comprising assets, drawing from historical data on the assets and market index performance.

Rationale: Index modelling assumes that there is a correlation between an asset's return and a market index. By analyzing the correlation and sensitivity between the asset and the market index, the expected performance and risk of the asset can be inferred.

Model building: Building an index model requires the selection of an appropriate market index as a benchmark, commonly including stock market indices such as the S&P 500, the Dow Jones Industrial Average, etc., as well as indices for other asset classes, such as bond indices or commodity indices. The relationship between the asset and the market index is then estimated through statistical methods, such as regression analysis, to determine the asset's beta coefficient (beta).

Beta coefficient: The beta coefficient measures the volatility of an asset relative to a market index. If an asset boasts a beta of 1, it implies that its price movement perfectly aligns with that of the market index; A beta exceeding 1 signifies that the asset's price experiences greater volatility compared to the market index, and vice versa.

Risk and return: The risk and expected return of an asset can be estimated based on its beta. High beta assets typically have higher expected returns but are associated with higher volatility and risk; low beta assets are relatively stable but also have lower expected returns.

Application: Index models are commonly used in asset allocation and risk management. Investors can choose a suitable asset portfolio according to their risk appetite and investment objectives, and achieve an optimal risk-return balance by adjusting the weights of different assets.

In the Index Model, the excess return is determined by

$$r_i - r_f = \alpha_i + \beta_i(r_m - r_f) + \varepsilon_i \tag{3}$$

Where r_f denotes the risk-free rate; r_m denotes the market return; α_i stands for alpha; β_i stands for the beta; ε_i denotes the residual return. The advantage of the mono-exponential model is that on the one hand, it optimizes the cumbersome integration of multiple covariance data in the Markowitz model, which means that the computational burden is reduced, and on the other hand, it also introduces the notion of common factors, which provides a completely new perspective for the in-

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depth scientific and objective investigation of systematic and idiosyncratic risks of a portfolio of securities.

Since this paper studies the Chinese stock market, the following constraints are imposed on the portfolio.

Constraint 1: “Free Problem”

For this condition, there are no further optimization constraints. If there are no constraints, this is used to track the performance of an optimized portfolio.

Constraint 2: “No Short Positions”

In the event of unusual market volatility or significant negative news, the CSRC may issue an announcement to temporarily suspend short-selling of some or all stocks in order to maintain market stability.

$$\omega_i \geq 0, for\ \forall \mathrm{i} \tag{4}$$

3. Results and Discussion

3.1. The results of Markowitz Model

From the figure1, it can be seen that the variance of the least-square difference of the Markowitz Model is 12.671% and the return is 1.481% in the unconstrained case.

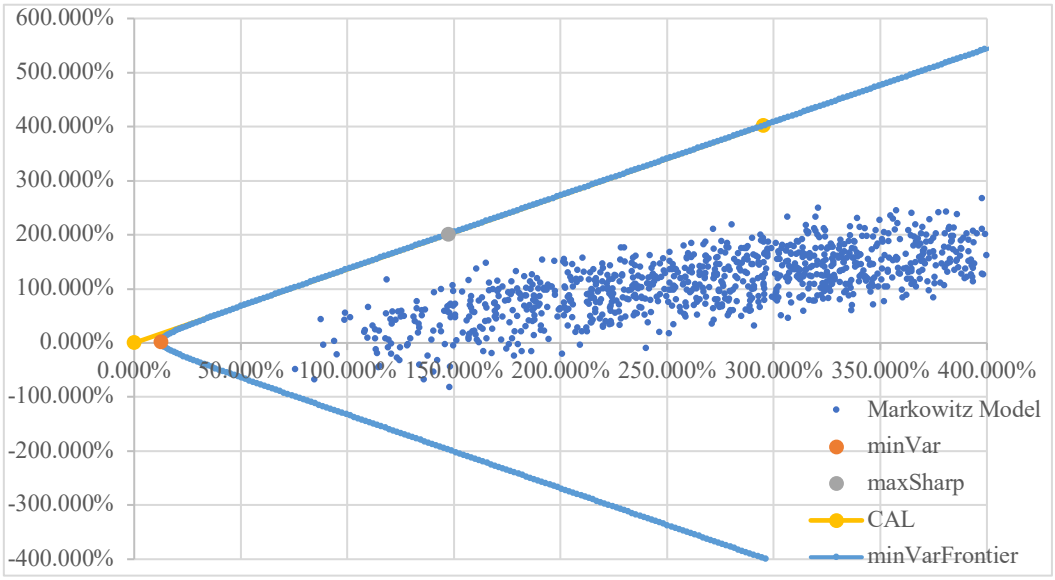

Figure 1: The results of Markowitz Model.

3.2. The results of Index Model

From the figure2, it appears that both the Index Model and the Markowitz Model exhibit similar minimum variance frontiers when not subjected to constraints, it's evident that the Index Model yields a higher return at comparable levels of risk. At the minimum variance point, the Index Model has a variance of 13.873% and a return of 2.352%.

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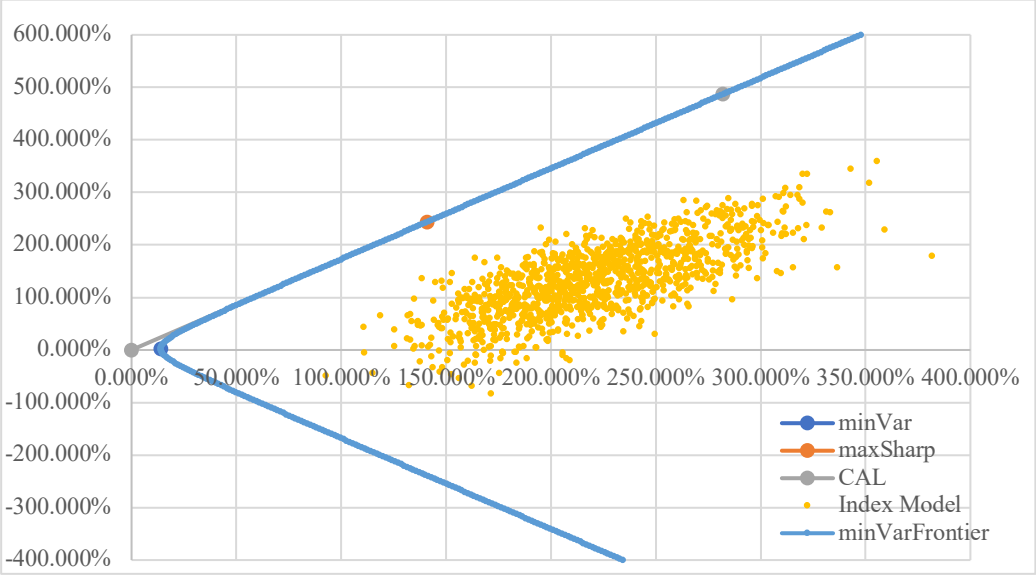

Figure 2: The results of Index Model.

3.3. Comparison

For the results of the two models, this paper provides a comparative analysis of the following three dimensions.

Return: The return in a portfolio is the amount of money an investor earns over a period of time, usually expressed as a percentage or in monetary units. Returns are one of the key measures of investment performance, reflecting an investor's assessment of the effectiveness of asset allocation and investment strategies.

Standard Deviation: A statistical indicator of the returns volatility in a portfolio is its standard deviation. Higher standard deviations indicate higher levels of risk and volatility in the portfolio's returns, respectively. Standard deviation is frequently used to quantify risk, and in order to attain the best possible risk-return balance, investors frequently aim to lower a portfolio's standard deviation while keeping a particular level of return.

Sharp Ratio: The Sharpe ratio expresses the excess return of a portfolio per unit of risk. It is frequently employed to evaluate a portfolio's risk-adjusted performance. Sharpe Ratio is calculated as (average return of the portfolio - risk-free rate) / standard deviation of the portfolio. For the same amount of risk, a portfolio with a greater Sharpe Ratio suggests a better return.

Constraint 1:

Table 2: The results of constraints 1.

	Min Variance			Max Sharp		
	Return	StDev	Sharp	Return	minVar	maxSharp
MM	1.481%	12.671%	0.117	200.793%	147.532%	1.361
IM	2.352%	13.873%	0.170	243.608%	140.995%	1.728

With no restrictions(table2), two models under the condition of minimum risk, Markowitz Model has smaller variance. It suggests that although the Index Model boasts a superior return and Sharpe ratio, the Markowitz Model entails lower risk. The higher Sharpe ratio indicates that the portfolio generates a higher excess return per unit of risk, meaning that the investor gains more return on risk. Under the condition of maximum Sharpe ratio for both models, Index Model has significant

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advantages with higher return and Sharpe ratio and less risk taken. Therefore, the Index Model is more advantageous for unconstrained conditions.

Constraint 2:

Table 3: The results of constraints 2.

	Min Variance			Max Sharp		
	Return	StDev	Sharp	Return	minVar	maxSharp
MM	0.238%	14.552%	0.016	33.919%	40.090%	0.846
IM	3.516%	14.062%	0.250	26.655%	20.584%	1.295

Assuming that shorting is not allowed(table3), the two models are minimized in terms of risk, it is clear that the index model is more advantageous because it has a larger return and Sharpe ratio along with a smaller variance. Meaning that the index model still allows the investor to earn higher returns with less risk. The two models, conditional on the maximum Sharpe ratio, show that although the index model has a smaller return, its variance is much smaller than that of the Markowitz model, and the corresponding Sharpe ratio is larger. Thus it can be argued that the index model still has an advantage when shorting is not allowed.

4. Conclusion

In this study, a selection of fifteen stocks within the emerging energy sector is assembled utilizing both the Markowitz model and the index model. Given the prohibition of short selling in the Chinese stock market, the analysis primarily concentrates on the portfolio outcomes under Constraint 2.

The previous comparison shows that the index model still has an advantage under restriction two. Under the condition of minimum risk, the investment weight of Shanghai Composite Index accounts for 74.776%, while no investment is made in Guangzhou Tinci Materials Technology, Zhejiang Huayou Cobalt, and Zhejiang Sanhua Intelligent Controls, implying that Shanghai Composite Index is the best choice if pursuing the minimum risk, while the three stocks that are not invested in may have greater risk. Under the condition of maximum Sharpe ratio, the investment weights on BYD Company Limited, Contemporary Amperex Technology, and EVE Energy are larger, accounting for 19.792%, 17.407%, and 16.553%, respectively, while the investment weights on Shanghai Composite Index, GEM, and Zhejiang Huayou Cobalt are 0%, which implies that investors are inclined to invest more in the initial three options once they have maximized the surplus return relative to the risk incurred.

The following two insights are drawn from the research of this paper.Firstly, after constructing the optimal portfolio, it can be obtained that the investment weights of BYD Company Limited, Contemporary Amperex Technology, and EVE Energy are higher, which means that in the current environment, these stocks have more investment value. Among them, BYD Company Limited and Contemporary Amperex Technology have higher weights in both models, which is not only useful for investors to construct portfolios using the portfolio model, but also helpful for investors who do not construct portfolios to choose individual stocks. Secondly, on the other hand, the research in this paper compares the two models and finds that the index model is better, which provides a certain reference to the selection method when investors go to choose the portfolio construction of the new energy industry, and the research in this paper can get the index model is better, which provides a foundation of evidence for the investors to choose the portfolio model.

Regarding the construction of portfolio models, there are many methods at this stage, but this paper does not make further comparisons in the study. Maybe there are better models compared to the two models in this paper, and more models can be used in the future to compare to get a model that is most suitable for constructing portfolios in the new energy industry for further research in the future.

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