Green Portfolio and Strategy of the Environmentally Friendly Fund in China Based on Sharpe Ratio -- Taking New Energy as An Example

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Abstract—The concept of environmental economics is in accordance with the pursuit of economic and environmental development in China at present, so the green economy has become important support. Under the energy structure of coal-based in China, new energy plays an important role in the further development of the green industry. And the correlation analysis also proves that the decline in carbon emissions will lead to the rise of new energy stocks' prices. Therefore, we analyze the optimal portfolio of the new energy green fund. Empirical analysis shows that China's new energy index and new energy stock portfolio in the investment portfolio can meet the pursuit of high returns, but its Sharpe ratio is still relatively low, so we need to pay more attention to its risk aversion function in the future use so that the new energy fund portfolio in economic and social benefits to achieve a balance.

Keywords—environmental protection funds; green portfolio; environmental economics; new energy; carbon emissions

1 INTRODUCTION

In the second half of the 20th century, due to the increase of global environmental problems and the gradual rise of modern environmentalism, some research fields in economics gradually shifted to environmental science, and the concept of environmental economics came into being [1]. R·Coase analyzed from the perspective of modern property rights theory, and used the micro-analysis of market failure to explain the economic roots of environmental problems in 1960 [2]; Hardin introduced the theory of externality and property rights in environmental economic issues in 1968; Kneese, Ayres and d Arge pointed out the essence of environmental pollution from an economic point of view and anticipated the future management of the environment by economic measures [3]; Gray and Hotelling analyzed the rent and intergenerational compensation policies of resources on the degree of non-renewable resources attrition respectively [4, 5]. Environmental economics integrates natural ecosystems into the scope of economic value, and links natural capital such as the ecological environment with social-economic systems, thus revealing the root causes of environmental and economic problems [6, 7]. At the same time, what kind of economic development method will be adopted in the study of environmental economics to ensure the minimal destruction of the environment and achieve sustainable social development becomes the basis for the effective resource allocation decision. Hence, in recent decades, as the consumption of natural resources intensified and environmental pollution becomes gradually serious, the

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application of environmental economics has become particularly important under the rapid development of the economy in the global [8].

After China's reform and opening-up in 1978, the economy developed rapidly, and in this process, it also produced problems such as the deteriorating environmental situation and came into notice. At the National Conference on the Development of Philosophy and Social Sciences in 1978, it was made clear that environmental problems are not only problems within the scope of natural science and technology engineering, but also closely related to socio-economic factors, and must be analyzed using social sciences such as economic theory. At present, China is in the new stage of 'new normal', in order to achieve the dual goal of stable economic growth and solving the environmental problems brought about by the extensive growth model, China's environmental awareness is gradually increasing. In 2016, People's Bank of China issued The Guidance on Building a Green Financial System in conjunction with seven ministries. This is also the first policy framework to support green financial development in the world which is relatively complete [9]. Since then, the government has continuously issued policies on six different aspects, they are green credit, green bonds, environmental information disclosure, green investment, green insurance, and environmental rights and interests trading market, to achieve a balance between the environment and the economy and promote green financial development [10].

As a special investment fund of the target for national energy conservation and emission reduction strategy and various environmental optimization and transformation projects, green fund not only will attract private capital attention to the environmental protection industry to promote low-carbon economic development but also can become a major driving force to promote international green financial cooperation, so the establishment of environmental protection green fund has become an important measure of China's ecological environment investment and financing reform and further promotion to the construction of ecological civilization [11]. In 2020, the government established a Green Development Fund Co. Ltd, which not only further meet China's needs for the protection of the ecological environment but also establish a healthy and effective fund operating model for value realization [12]. In addition, under the concept of "carbon neutrality", China further promotes the development of new energy sources, bringing a better environment for new energy enterprises. This paper will also test the relationship between carbon emission and new energy, aiming to promote the development of new energy with a better empirical reference basis [13].

Reducing carbon emissions is also an important measure to develop a green economy, with the global environmental problems becoming more and more prominent, how to control carbon emissions has gradually become one of the most important issues in the world. The adoption of the United Nations Framework Convention on Climate Change in 1992 was the first international cooperation to achieve comprehensive control of greenhouse gas emissions; Kyoto Protocol, which was adopted in 1997 and entered into force in 2005, formulated three flexible emission reduction mechanisms to control national greenhouse gas emissions, among them, the Clean Development Mechanism allows countries to develop their economies while reducing emissions; the Paris Agreement adopted in 2015 gave the carbon market an important role in reducing carbon dioxide emissions and promoted the development of the international carbon trading market through the proposed sustainable development mechanism. As a highly industrialized country, in China, coal is still the main energy source in the short term, and the space for energy demand growth continues to increase, so it is urgent to improve the energy structure and improve energy efficiency [14]. The 14th Five-Year Plan released in 2021 clearly states that the development of

new energy sources is of vital importance to China by reducing the intensity of carbon emissions and formulating a plan of action for carbon emissions by 2030.

Bello demonstrated the alternative possibilities between renewable and non-renewable energy through empirical analysis and recommended that the Government need to develop renewable energy as fast as possible [15]; Zou et al. proposed new energy, as the main role of the 3rd energy conversion, played an important role in carbon neutrality, especially artificial carbon conversion technology can further connect new energy and fossil energy sources, thus we can transform between this two better [16]. Because of the important role of new energy development in reducing carbon emissions, many countries attach more attention to the development of new energy technologies, and investors continue to include new energy stocks in green funds as their investments [17]. For example, the European Union has established the Global Energy Efficiency and Renewable Energy Fund (GEEGEF) to promote green investment in renewable energy sources, including new sources of energy. Therefore, from the perspective of environmental economics and carbon emission reduction, the development of environmental protection funds is conducive to promoting the further integration of environmental and economic issues, and as a major measure to promote the development of new energy to promote low-carbon economic development [18, 19].

The contribution of this paper to the investment portfolio of environmentally friendly funds constructed by new energy will be reflected in three aspects: (1) Through the in-depth study of the green fund, the relevant literature of environmental economics can be enriched; (2) New energy stocks will be included in the scope of environmental protection green fund, and a more effective green fund investment strategy will be constructed from different indicators; (3) In the background of China's new normal development, it provides empirical support for promoting the construction of national green industry and achieving the goal of green economic development.

The remaining of the paper is structured as follows. Section 2 proves the correlation between carbon emissions and new energy stock prices. Section III conducts new energy green portfolio data processing and empirical research. Section 4 summarizes the conclusion and suggestion of this paper.

2 THE PROOF OF CORRELATION BETWEEN CARBON EMISSIONS AND NEW ENERGY STOCK PRICES

Qin Tiancheng came to a conclusion that coal price will have a positive impact on the price of new energy companies after analyzing the EUA price through the VAR model and CAPM-GARCH model [20]; Bu Wenke and Zhao Mengen found that the new energy stock price is positively affected by the price of carbon emission right through VAR model, impulse analysis and other empirical methods [21]; In the Global Carbon Emissions Trading System, it is based on the principle of "total control and trading" and the quotas and pricing are based on market supply and demand. To sum up, carbon emissions, to a certain extent, affect the stock price of new energy companies through cost, income, and other factors, thus having a certain impact on the new energy index. When the carbon emission is relatively low, it shows that the society generally attaches importance to new energy and will choose to use new energy more, which will have a positive impact on the economic benefits of new energy enterprises; On the contrary, when the carbon emission is relatively high, the business environment and operating conditions faced

by new energy enterprises will not be dominant. Therefore, the economic benefits of new energy-listed enterprises will be further reduced, and the new energy-related stock prices will decline.

2.1 Variable selection and data collection

For the correlation between carbon emissions and new energy stock price, we select carbon emissions as the independent variable and new energy stock price as the dependent variable. The data of independent variables are China's total carbon emissions data from 2011 to 2019, with the unit of $MtCO_2$ (Data source: http://www.globalcarbonatlas.org/en/CO2-emissions). Because the new energy index of China Securities (000941) is composed of a certain number of shares of listed companies with new energy business, it can reflect the overall performance of various companies in the new energy industry to a certain extent. Therefore, the average value of China Securities' new energy index from 2011 to 2019 (excluding missing trading days) is used as the new energy stock price data, and the data source is the Wind database.

2.2 Correlation test and results

Based on the data collected above, the correlation coefficient of the correlation between carbon emissions and new energy stock price from 2011 to 2019 can be calculated, and we got the correlation statistical chart as follows. From this chart, we know that the relationship between carbon emissions and the new energy index is close to linear, so we can use the linear correlation coefficient r to describe the degree of correlation between them. The data model is

$$r(X, Y) = \frac{Cov(X,Y)}{\sqrt{Var(X) * Var(Y)}} \quad (1)$$

and the final correlation coefficient is equal to -0.5305, which shows that there is a negative correlation between them, so it can be verified that with the increase of carbon emissions, new energy stock prices decline. And the absolute value of the correlation coefficient is 0.5305 > 0.5, which means that the correlation between the two is relatively strong, which can further prove that the construction of a new energy portfolio can affect the development of the green industry to a certain extent.

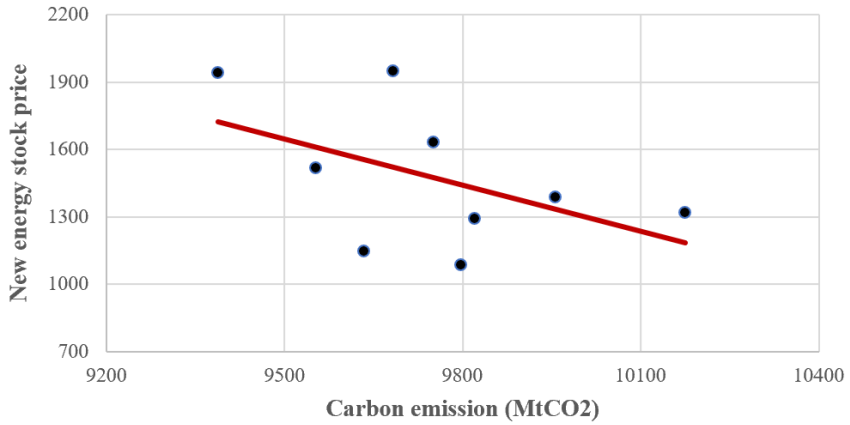

Figure 1 Correlation chart of carbon emissions and new energy stock prices

3 EMPIRICAL MODEL AND DATA PROCESSING OF NEW ENERGY GREEN PORTFOLIO

3.1 Basic theory

In 1952, American economist Markowitz put forward the portfolio theory for the first time, which mainly included two aspects: mean-variance analysis method and portfolio efficient frontier model. Markowitz's portfolio theory has been proved to be effective and widely used in the practice of the developed securities market. Portfolio theory regards people's investment behavior as choosing between uncertain returns and risks and uses two indicators to refer to these two important factors, namely mean and variance. The portfolio theory assumes that all investors are "rational investors", which means the expected return is maximized at a given expected risk level, and the expected risk is minimized at a given expected return level. The optimal portfolio can be described by a curve, that is the effective portfolio frontier [22].

The efficient frontier can provide a clear minimum variance to optimize the portfolio, but it cannot guarantee the high yield of the portfolio. Therefore, Sharpe's law was proposed in 1966, it comprehensively considered the return and risk, and defined the sharpe ratio as the ratio of return and variance of the portfolio, to maximize the return of unit risk in this portfolio. It has become one of the common indicators in fund performance appraisal. Especially in the investment portfolio under the concept of diversified investment, the yield of stocks is relatively high, as well as the risk. The combination of national debts and bank deposits can diversify risks, adjust profits, and increase the Sharpe ratio of the portfolio. Markowitz mean-variance analysis model is as follows:

The expected return of the portfolio is:

$$E(r_p) = \sum_{i=1}^{n} w_i E(r_i) \tag{2}$$

The variance of the portfolio is:

$$\sigma_p^2 = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{j \neq i, j=1}^{n} w_i w_j \sigma_{ij}$$

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

Where w_i means the weight of the asset I in the portfolio, with $\sum_{i=1}^{n} w_i = 1$, $E(r_i)$ means the expected return of the asset I, $E(r_p)$、σ_p^2 is the expected return and variance of the portfolio respectively.

When the income is fixed, the variance is the smallest; When the variance is constant, the profit is the largest.

3.2 Data collection and processing

At present, the main new energy green funds in China invest in bank deposits, corporate bonds, government bonds, stocks, and other different assets. Therefore, in this empirical study, the fund portfolio also mainly invests in bank deposits, government bond index, corporate bond index, new energy index, Shanghai Stock Exchange Index, and new energy company stocks. The selected data period is from January 4, 2016, to December 31, 2020. Among them, bank deposits are based on an overnight interest rate of Shanghai interbank offered rate, government debt, and

corporate bond data refer to government debt index and corporate bond index of Shanghai Stock Exchange, new energy index and Shanghai stock index are from Shanghai Stock Exchange, and the data source is Wind database system.

Because the stock and index data provided by the Wind database are the closing price of each day, but not the rate of return on investment, so we need to get the required data through certain calculations based on those data. In the process of establishing the portfolio in this paper, the data we need is the rate of return, the average rate of return, and the standard deviation of the rate of return of each asset.

The rate of return of stock and bond investment refers to the rate of return of investment in a certain period of time. In this paper, the daily rate of return of each asset is calculated by taking the day as the unit, which means the daily rate of return of stock or bond can be obtained by dividing the difference between the closing price of stock or bond on that day and the previous trading day by the closing price of the previous trading day, which can be expressed in a formula:

$$R_{it} = \frac{P_{it} - P_{it-1}}{P_{it-1}} \tag{4}$$

Where Rit represents the return rate of stock I on the day t; $P_{it}$and P_{it-1}represent the closing price of stock I on day t and day t-1, respectively.

The standard deviation of each stock and bond is used to measure the difference between the daily return rate and the average rate of return, which can be expressed in a formula:

$$\sigma_i = \sqrt{\frac{\sum(r_{it} - \overline{r_t})^2}{n}} \tag{5}$$

3.3 Empirical model

In this paper, the function of the optimal green fund portfolio is set as the maximum Sharpe ratio, so the portfolio model can be expressed by the following formula:

$$\text{max: Sharpe Ratio} = \frac{E(r_p) - r_f}{\sigma} = \frac{\sum_{i=1}^{n} w_i \mathrm{E}(r_i) - r_f}{\sum_{i,j=1}^{n} w_i w_j \sigma_{ij}} \tag{6}$$

Where σ means the standard deviation of the portfolio, $\mathrm{E}(r_p)$ means the expected return of the portfolio, r_f means the risk-free interest rate. According to <The measures for the operation and management of securities investment funds publicly raised >, when a fund manager invests in securities with fund property, it is not allowed that one fund holds securities issued by one company which has its market value exceeds 10% of the net asset value of the fund; Therefore, it is necessary to restrict the weight of each stock, so we take the data from October 2020 to December 2020 as the period, and calculate the average closing price of each stock as its market value, and it needs to be ensured that the product of the weight of each stock w_i and the average closing price is no more than 10%, which can be expressed as:

$$\frac{w_i * \overline{\mathrm{P}}\mathrm{I}}{\sum_{i=1}^{n} w_i \overline{\mathrm{P}}\mathrm{I}} \leq 10\% \tag{7}$$

Where $\overline{\mathrm{P}}\mathrm{i}$ is the average closing price of the asset i in the three-month data.

Sharpe's ratio requires the portfolio to consider both yield and risk, so its environmental protection fund is a balanced hybrid fund, which requires that the allocation ratio of bonds and stocks are roughly the same, about 40% - 60%. It can be expressed as follows:

$$40\% \leq w_{xin} \leq 60\%; \tag{8}$$

$$40\% \leq w_{gong} + w_{guo} \leq 60\% \tag{9}$$

Where w_{gong} refers to the proportion of corporate bonds in the investment portfolio, w_{guo} refers to the proportion of government bonds in the investment portfolio, w_{xin} refers to the proportion of new energy index or new energy stock portfolio in their respective portfolios.

This paper mainly uses RStudio to calculate the correlation coefficient, average yield, standard deviation, and effective boundary of the green portfolio of the new energy green fun and make a further comparative analysis, to obtain the best portfolio of the new energy green fund and put forward relevant suggestions.

3.4 Sample selection

Firstly, we need to compare the correlation, daily average yield, the standard deviation of yield, and the Sharpe ratio of each asset. From table 1, it can be seen that among the five data of bank deposit, national debt index, corporate bond index, Shanghai Stock Exchange Index, and new energy index, the Sharpe law of Bank deposit reaches 4.463736 at the highest, so it can continuously obtain stable income with extremely low risk, The national debt index and corporate bond index take the second place, and the Sharpe ratio of new energy index is relatively low, but its daily average yield is the highest among the five, reaching 0.052549. Therefore, the new energy index is an investment option with high risk and high yield, which is in line with investors' investment intention and expectation to a certain extent. In contrast, the Shanghai stock index has the lowest Sharpe ratio of 0.009544. According to the data, the risk (i.e., standard deviation of yield) of the Shanghai stock index is much higher than that of the other three investment items except the new energy index, while the daily average yield is also lower than that of national debt index and corporate bond index. And due to the strong correlation between the Shanghai stock index and the new energy index, in the construction of a new energy portfolio, the Shanghai stock index is not the choice.

Table 1 Correlation coefficients and related data among various investment items

Related data of investment items	**Different optional investment items**				
	Bank deposit	***National debt index***	***Corporate bond index***	***Shanghai Stock Exchange Index***	***New energy index***
Bank deposit	1	-0.07994	-0.1263	-0.03128	-0.05116
National debt index	-0.07994	1	0.34842	-0.07249	-0.05289
Corporate bond index	-0.1263	0.34842	1	0.03946	0.06255
Shanghai Stock Exchange Index	-0.03128	-0.07249	0.03946	1	0.8362
New energy index	-0.05116	-0.05289	0.06255	0.8362	1

Daily average yield (%)	0.006093	0.014184	0.017287	0.011107	0.052549
Standard deviation of yield	0.001365	0.039182	0.023369	1.163763	1.692999
Sharpe ratio	4.463736	0.362245	0.739741	0.009544	0.031039

Because this paper adopts an active asset allocation strategy in the construction of a portfolio, we consider both the new energy index and the new energy listed company stock as a reference investment item. Five companies listed before 2016 have been selected by random selection, and three listed companies with high comprehensive data levels are selected as representatives (Northern Huachuang, Sunshine power, BYD) through data comparative analysis among the five companies to make up of the new energy stock portfolio. Both the daily average return and the Sharpe ratio of the new energy stock portfolio are much higher than the daily average return of the new energy index, so it can be used as one of the optimal investment portfolios of new energy.

Table 2 New energy listed company stock data

Related data of each company	**New energy listed company**			
	Northern Huachaung	***Sunshine Power***	***BYD***	***New energy stock portfolio***
Daily average yield (%)	0.253472	0.157658	0.130992	0.180707
Standard deviation of yield	3.650739	3.629921	2.564862	2.506994
Sharpe ratio	0.06943	0.043433	0.051072	0.072081

There will be two investment portfolios to be constructed in this paper. They are investment portfolio I composed of bank deposits, corporate bond index, national debt index, and new energy index; Investment portfolio II composed of bank deposits, corporate bond index, national debt index, and domestic new energy enterprises.

3.5 Results and discussion

This paper calculates and compares the optimal investment results of two different portfolios by RStudio, and obtains the optimal proportion matching results of two different portfolios as follows:

Table 3 Optimal portfolio data comparison

Related data of each portfolio	**Optimal portfolio**	
	Portfolio I	***Portfolio II***
Daily average yield (%)	0.03	0.08
Standard deviation of yield	0.67	1
Sharpe ratio	0.04	0.08

Bank deposit's proportion	0.05	0.05
National debt index's proportion	0.25	0.25
Corporate bond index's proportion	0.3	0.3
New energy index's proportion	0.4	—
New energy stock portfolio's proportion	—	0.4

The highest Sharpe ratio is selected as the evaluation standard between these two different portfolios. Because bank deposits and corporate bonds have Sharpe's ratios which are far higher than other indicators, the proportion in each portfolio is the maximum within the specified range. And because the Sharpe ratio of the new energy index and new energy stock portfolio is low, therefore, the proportion of them in each portfolio is the minimum value within its specified range. However, due to the characteristics of high yield and high risk of stocks, the average daily returns of the two portfolios are much higher than those of bonds and bank deposits, which proves that the new energy index and new energy stock portfolio have considerable investment value.

From the data comparison between portfolio I and portfolio II, it can be seen that due to the restriction of investment proportion and the sharpe ratio of each asset, each asset in the two portfolios has the same investment proportion when taking the highest Sharpe ratio as the target. The only change is that the new energy investment of each portfolio is new energy index and new energy stock portfolio respectively. Under the same proportion of investment, the new energy stock portfolio can bring higher return and risk for the portfolio, and the Sharpe ratio will be higher than the new energy index portfolio in the end, so it can be proved that the new energy stock portfolio has higher value in the new energy green fund portfolio.

Given that both portfolios have the characteristics of environmentally friendly investment due to new energy investments in them, portfolio II has a higher Sharpe ratio because of the high return of the new energy stock portfolio, which makes it better than Portfolio I. Meanwhile, Portfolio II may have a higher Sharpe ratio because of its extremely low risk if no stocks of new energy companies are included, but its yield will also drop sharpely, and it will not meet the need of environmentally friendly fund investment. Therefore, it is scientific to use the Sharpe ratio to select a portfolio with more value from the investment portfolio that contains the new energy index and the new energy company stock portfolio.

The analysis results of this paper are similar to those of Weiping and Shuhao in terms of yield and risk of green funds based on single factor evaluation indexes such as sharpe index or Treynaud index and Carhart four-factor model indexes [23]. The sharpe ratio of the green fund portfolio is smaller than that of traditional market benchmark investment, which indicates that there is still a problem of risk diversification in the new energy green investment direction. In addition, in the paper of Chen Zhiguo, Yang Tianjie, and Zhang Chi [24], which takes the minimum CVaR as the optimal goal of pension fund's new energy green portfolio, they also

conclude that compared with the new energy index, the addition of new energy stock portfolio can bring greater benefits to the portfolio, which is consistent with the conclusion of this paper.

4 CONCLUSION

This paper proves that carbon emissions and new energy index have a certain correlation through two empirical analyses, so a new energy index or new energy stock portfolio can be added to the green fund portfolio. These two investment projects also have a certain investment value because of their high return characteristics, especially the new energy stock portfolio, which has a greater investment value than the new energy index under the same proportion of the portfolio.

In this regard, in the green portfolio of new energy, we should first ensure the proportion of new energy investment (such as new energy index or new energy stock portfolio), adhere to the dual benefits of ecological and environmental of the green fund, and get a balance between them, to realize the multiple goals of the green fund in economy, ecological environment and social benefits. This determines that green investment portfolio cannot continuously expand the proportion of new energy investment in pursuit of its policy objectives and environmental benefits, which will damage its economic benefits; We can't stick to the economic benefits of high-income risk ratio and ignore its function of promoting the development of new energy.

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