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Style Drift and Performance Evaluation of Green Funds in China

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Abstract: Based on data of China's open equity and partial equity hybrid green funds from 2018 to 2022, this paper conducts the sharp style analysis model to construct green fund style drift indicator, and apply the TM model to construct stock selection and timing indicators. Moreover, this paper constructs a panel fixed-effect model to empirically analyze the impact of green fund style drift, stock selection and timing on green fund performance. This research finds that there is a drift of investment style in green funds. Such style drift and timing have a negative impact on the performance of green funds. Stock selection has a significant positive impact on green funds. Furthermore, this research introduces style drift, stock selection and timing indicators into green fund performance evaluation, and use principal component analysis method to build a green fund performance-evaluation system. Then, this paper applies the rating system to the existing green fund market and effectively supplements the existing rating system.

Keywords: green fund, style drift, stock selection and timing, principal component analysis, performance evaluation

1. Introduction

As an important part of supporting green investment in China's securities market, green funds have attracted much attention from individual and institutional investors since they first entered the market because of their investment philosophy of taking into account economic and environmental benefits. Green funds usually refer to the securities investment green funds of listed companies with investment value that invest publicly raised funds in green related fields such as low-carbon economy, environmental protection and new energy.

The performance and market feedback of green funds reflect the development status and recognition of green finance to a certain extent. In recent years, with the guidance and support of national policies, China's green fund has developed rapidly and vigorously, and has great development potential. Compared with traditional funds, green funds should consider not only personal investment interests but also social and environmental public interests, and "finance and environment" are their dual development goals. With the enhancement of people's awareness of environmental protection and the increase of relevant policy support, the demand for green investment has gradually increased, which provides many opportunities for the development of green funds. From the perspective of investors, the companies that green funds choose to invest in

DOI: 10.54254/2754-1169/57/20230528

have low environmental risks, high production efficiency and green innovative technologies, which have greater profit margins and sustainable development potential.In the long run, investing in such funds may achieve better or even better market performance than traditional funds. In addition, successful green funds can also bring social benefits and environmental returns other than direct returns to investors, making investors more inclined to invest in green funds, further affecting the relationship between green fund performance and its capital flow. However, compared with other green financial investment tools, China's green fund started late, the relevant policies of green fund need to be improved, the evaluation mechanism needs to be optimized, and there may be "style drift", which makes the fund market incentive mechanism ineffective. Based on the existing research, this paper adopts a more effective evaluation method for the performance of green funds, explores whether the green fund market has style drift like the traditional fund market, and studies the stock selection and timing ability of green fund managers, hoping to draw more perfect conclusions for market participants to refer to.

2. Literature Review

2.1. Performance of Green Funds and Traditional Funds

Kollner used EIO-LC model to evaluate, and the results showed that sustainable investment funds had better environmental performance than traditional funds [1]. Muñoz analyzed the financial performance and management capabilities of 18 American green funds and 89 European green funds, and found that compared with other funds, green funds did not perform poorly [2]. Matsuda uses the shortage function method to evaluate, and the results show that compared with traditional funds, social responsibility investment funds and green funds have better performance [3]. Wei and Shu conducted a comparative analysis, and the results showed that the risk adjusted return of the national green fund was lower than that of the traditional fund and the market level [4].

However, Shi pointed out that there is no significant difference between the performance of China's green funds and the financial performance of traditional funds and other socially responsible investment funds [5]. Zou also made a comparative analysis of the two, and the results also showed that there was no significant difference between the performance of green funds and traditional funds [6]. Some scholars also believe that because green funds have more limitations than traditional funds, green funds have lower returns. Silva evaluated the performance of green funds in the United States and Europe, and the results show that when short-term interest rates are below normal or the economy is depressed, the yield of green funds is often lower than that of traditional funds [7]. Reboredo selected a sample of clean energy mutual funds from 2010 to 2016 to study their financial performance. The results show that the performance of clean energy fund returns and risk compensation is worse than that of traditional funds, and investors should bear the "green" premium cost of the fund [8].

2.2. The Style Drift of Green Funds

Fund style drift refers to the deviation of the actual investment style of the fund from the established investment style. With the hot sales of the fund, investors' excessive pursuit of the past performance of the fund will also lead green fund managers to change their investment strategies in pursuit of better performance, resulting in significant changes in their green fund investment style. At present, many domestic scholars have analyzed the style drift of traditional funds, but few scholars have specifically selected green funds as the research object to explore the impact mechanism of performance ranking on their investment style drift. It is of great practical significance for investors to allocate green assets to study the mechanism of performance ranking affecting green fund style drift.

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As for the quantification of fund investment style drift, there are two methods of ex ante analysis and ex post analysis in the literature. Post hoc style analysis is often used in academic research and practical applications, which can be divided into return based style analysis (RBSA) and holding based style analysis (HBSA). In the research of RBSA method, Sharpe judges the investment style of the fund according to the sensitivity of the fluctuation of fund return to the fluctuation of asset return of each style based on the multi factor regression model [9]. Idzorek and Bertsch the style drift score based on Sharpe model measures the volatility of fund portfolio changes to measure the degree of investment style drift [10]. Bar et al. uses the regression coefficient of Carhart's four factor model to calculate the average standard deviation of the coefficient to measure the drift of investment style [11]. Xu and Song combined RBSA method with fractal dimension and economic elasticity theory to define the price elasticity fractal dimension of investment style drift, and obtained the threshold of fund investment style drift according to the price elasticity fractal dimension and the consistency benchmark of investment style [12]. In the study of HBSA method, Grinblatt and Titman use the weight change of stocks in the portfolio to measure the change of portfolio [13]. Wermers measures the sum of each style dimension through fund shareholding information, and then obtains the fund style score to study style drift [14].

2.3. Stock Selection and Timing Ability of Fund Managers

As for the stock timing ability of fund managers, Treynor and mazuy proposed TM model, which analyzed the market timing ability and stock selection ability of green fund managers at the same time for the first time by adding a quadratic term. Subsequently, henriksson and Merton proposed HM model, which added a virtual variable representing bull and bear market on the basis of TM model to investigate the stock timing ability of green fund managers under different market trends.With the continuous development of the green fund market, researchers also found that in addition to market timing ability, which can help green fund managers judge future market trends in order to rationally allocate assets and control risk exposure, other style timing ability such as scale and value is also important. Desrosiers et al. used a four factor TM style timing model to decompose the style timing returns in the international stock market from 1975 to 2003, and found that value timing and momentum timing can significantly improve portfolio performance [15]. Swinkels and Tjong-A-Tjoe used four factor TM and HM models to test whether American fund managers could timing the four investment styles of Carhart from 2001 to 2005, respectively. The results showed that fund managers not only had market timing ability, but also could timing the direction of value and momentum, but did not have timing ability for small/large capitalization companies [16].

Based on the above analysis, this paper takes China's open equity and partial equity hybrid green funds from 2018 to 2022 as the research object, uses sharp strong model to construct green fund style drift index, and uses TM model to construct stock selection timing index. Construct a panel fixed effect model to empirically analyze the impact of green fund style drift and stock selection timing on green fund performance. Further introduce style drift and timing stock selection indicators into green fund performance evaluation, and use principal component analysis method to build a green fund performance evaluation system.

The reminder of this paper is organized as follows: A description of the Green Fund is provided in Section2, along with a review of previous literature. Section3 describes the construction of three indicators that affect the performance of green funds. In Section4, the empirical results are presented. In Section5, this research establishes and applies the green fund performance evaluation model. The conclusion is provided in Section6.

DOI: 10.54254/2754-1169/57/20230528

3. Index Construction

This paper measures the style timing ability of China's open stock and hybrid green funds by introducing style drift index and stock timing ability index.

3.1. Style Drift Indicator

The sharp style strong model equation of domestic open end green funds can be expressed as:

$$R_i = \lambda_{i,1} F_1 + \lambda_{i,2} F_2 + \cdots + \lambda_{i,j} F_j + e_i \tag{1}$$

$$\sum_{i=1}^{j} \lambda_{i,j} = 1 \tag{2}$$

$$\lambda_{i,j} \geqslant 0 \tag{3}$$

The Sharpe model calculates Sharpe coefficients while satisfying the objective function. In the model, the coefficient is estimated as a constrained Quadratic programming method, and the style corresponding to the maximum sensitivity is the investment style of green funds. The model is equivalent to finding the optimal programming parameter value when the residual variance of the return rate is the smallest, which satisfies:

$$\text{Min Var}(e_i) = \text{Min Var}(R_i - \lambda_{i,1} F_1 + \lambda_{i,2} F_2 + \cdots + \lambda_{i,j} F_j) \tag{4}$$

$$\sum_{i=1}^{j} \lambda_{i,j} = 1 \tag{5}$$

$$\lambda_{i,j} \geqslant 0 \tag{6}$$

The indicator for evaluating the effectiveness of this model is the determine ability coefficient index $R^2=1-\text{var}(e_i)/\text{var}(R_i)$, which represents the degree of explanation of green fund style on returns. The larger the indexR^2, the higher the degree of explanation of style on green fund returns. From the overall effect, $R^2$is expressed as the contribution of green fund asset allocation to green fund returns.

Idzorek and Bertsch (2004) proposed an SDS indicator to quantify the degree of investment style drift. SDS measures the degree of style drift by measuring the volatility of investment portfolios on different styles of assets, derived from the Sharpe model equation mentioned above. The calculation formula is as follows:

$$SDS = \sqrt{\text{var}(\lambda_{i,1}) + \text{var}(\lambda_{i,2}) + \cdots + \text{var}(\lambda_{i,j})} \tag{7}$$

Among them, $\lambda_{i,j}$ represents the regression parameter of the green fund return rate in the style analysis equation in the formula. The higher the SDS, the higher the degree of style drift.

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3.2. Stock Selection and Timing Ability Indicators

Treynor and Mazuy (1966) pointed out that a quadratic term $(Rm-R)^2$ should be added to the market model when measuring the stock selection and timing abilities of green fund managers. They believe that green fund managers with the ability to select stocks at the right time will increase risk in pursuit of greater excess returns when the market trend rises, and reduce risk in order to ensure fund safety when the market trend drops. Therefore, the characteristic line will show a continuously increasing slope curve. The T-M model is shown in formula:

$$R_{j,t} - R_{ft} = \alpha_j + b_j RmRf_t + c_j RmRf_t\text{^}2 + \varepsilon_{j,t} \quad (8)$$

In equation, α_j is the index of securities selection ability, and c_j is the index of market opportunity ability. If c_j is positive, it indicates that the market timing ability does exist. If α_j is positive, it indicates the existence of securities selection ability.

4. Empirical Analysis

4.1. Data Selection

The data for this article are from Wind database. Due to the late development of green funds in China, there is no authoritative classification of green funds at present. This paper chooses 62 green funds in the ten year report on China's responsible investment as the research object. In this paper, green funds are screened under the following conditions: (1) green funds in wind database are selected as stock and hybrid green funds. (2) Choose green funds with a scale of more than 200 million yuan. (3) Choose green funds that have been established for more than two years. (4) Remove the terminated green funds. A total of 29 green funds were selected as research samples in this paper.

In this paper, semi annual data are used, and the sample interval is unbalanced panel data from January 1, 2018 to December 31, 2022, totaling 5 years and 10 semi years.

4.2. Variable Selection

4.2.1. Selection of Explanatory Variables

Sharp ratio (SHA) and net value growth rate (NWGR) are used to measure the performance of green funds. Sharp ratio is equal to the difference between the expected return of green funds and the market return, that is, the ratio of excess return to the standard deviation of green fund returns. The higher the sharp ratio, the better the performance of the green fund; Net value growth rate refers to the growth rate of net asset value of green funds in a certain period. Net asset value is the balance of the total market value of green fund assets after deducting liabilities at a certain point in time, which represents the rights and interests of green fund holders. When the net value growth rate is used to measure the performance of green funds, the greater the net value growth rate, the better the performance of green funds.

4.2.2. Control Variable Selection

In order to more accurately measure the relationship between industry allocation and green fund performance, other variables that may affect green fund performance need to be controlled. Referring to the model setting of Kong et al. (2010), this paper selects the net value scale, duration, stock investment ratio, capital flow, volatility and turnover rate of green funds as control variables, and the specific settings are as follows:

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Net value size of Green Fund (SIZE): refers to the balance of the total market value of green fund assets calculated at fair price after deducting liabilities at a certain time point, and makes natural logarithmization.

Duration (DUR): refers to the duration of the green fund at a certain time point, in years, with natural logarithmization.

Stock investment ratio (SIR): refers to the share of stock assets in the portfolio of common green funds.

Capital flow (FLOW): the net cash flow inflow of green fund in this period measured by the growth rate of net assets of green fund, and the specific calculation method is as follows:

$$FLOW_{i,t}=\frac{TNA_{i,t}-TNA_{i,t-1}\times(1+r_{i,t})}{TNA_{i,t-1}} \quad (9)$$

Among them, $TNA_{i,t}$ refers to the total net asset value of Green Fund i in period T\t, $TNA_{i,t-1}$ indicating the total net asset value of Green Fund I in period t-1, $r_{i,t}$ indicating the return rate of green fund in period t.

Volatility (VOL): refers to the volatility of green fund returns.

4.3. Empirical Results

4.3.1. Descriptive Statistics

Table 1 shows the descriptive statistics of each variable. Explained variables. It shows that different green funds have different ability to control risks and obtain returns. Excellent green fund portfolios can obtain higher returns while controlling risks, while green funds with poor market performance have negative performance. Among the explanatory variables, the average SDS score of green funds is 0.247, indicating that some green funds have style drift.

Table 1: Descriptive statistics of variables.

Variable	Mean	Std.Dev.	Min	Max
DUR	1.981	0.461	0.693	2.833
FlOW	0.2	1.056	-0.821	9.015
NWGR	0.102	0.223	-0.316	0.873
SDS	0.247	0.113	0.03	0.619
SEL	0.001	0.002	-0.002	0.006
SHA	0.043	0.1	-0.162	0.234
SIR	0.895	0.078	0.556	0.997
SIZE	21.025	1.337	17.21	23.833
TIM	-0.518	9.748	-38.382	19.29
VOL	26.327	6.951	9.662	44.373

4.3.2. The Impact of Style Drift on the Performance of Green Funds

Table 2 is the regression results of style drift indicators on green fund performance. From the perspective of core explanatory variables, sharp ratio and net value growth rate are used to measure green fund performance respectively. In the case of sharp ratio, the impact of style drift on green fund performance is not significant and negatively correlated; In the case of using the net value growth rate, the impact of style drift on the performance of green funds is significantly negatively

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correlated. From the perspective of control variables, the size of green funds in the two cases has no significant impact on performance.

Table 2: Style Drift and Fund Performance Regression Results.

Variate	Coefficient(Sharpe)	Coefficient(NWGR)
C	-0.07	-0.15
SDS	-0.085	-0.236*
DUR	-0.02	-0.053*
SIR	0.164**	0.24
FlOW	0.027***	0.071***
VOL	0	0.004*
SIZE	0.001	0.004
R^2	0.111	0.168
F	5.273	8.52

4.3.3. The Impact of Timing Ability on the Performance of Green Funds

Table 3 shows the regression results of green fund managers' stock selection ability on green fund performance. From the perspective of core explanatory variables, timing ability has a significant negative correlation with green fund performance in two cases; Among them, the impact on sharp ratio is significant at 5% level, and the impact on net value growth rate is significant at 1% level. From the perspective of control variables, except for the duration of green funds, the size of green funds and volatility, they all passed the significance test. According to the regression results, it can be concluded that the timing ability of green fund managers has a significant negative impact on the performance of green funds, and the timing ability of green fund managers may have a negative effect on the performance of green funds.

Table 3: Timing Ability and Fund Performance Regression Results.

Variate	Coefficient(Sharpe)	Coefficient(NWGR)
C	-0.086	-0.189
TIM	-0.001**	-0.004***
DUR	-0.015	-0.038
SIR	0.169**	0.249
FlOW	0.027***	0.072***
VOL	-0.001	0.002
SIZE	0.001	0.004
R^2	0.12	0.19
F	5.765	9.944

4.3.4. The Impact of Stock Selection Ability on the Performance of Green Funds

Table 4 is the regression results of green fund managers' stock selection ability on green fund performance. In both cases, the impact of stock selection ability indicators on green fund performance is significant at the level of 1% and the coefficient is positive. Green fund managers with stronger stock selection ability will have better performance. From the perspective of control variables, except for the duration and the size of green funds, other control variables passed the significance test.

DOI: 10.54254/2754-1169/57/20230528

Table 4: Stock Selection Ability and Fund Performance Regression Results.

Variate	Coefficient(Sharpe)	Coefficient(NWGR)
C	0.002	0.012
SEL	44.078***	104.754***
DUR	-0.004	-0.01
SIR	0.097*	0.083
FlOW	0.009**	0.029***
VOL	-0.002***	-0.001
SIZE	0	0
R^2	0.57	0.687
F	56.121	93.067

5. Performance Evaluation of Green Funds

In the research on the construction of fund performance evaluation system, scholars generally take risk adjusted income indicators as the core of evaluation, in addition to income, risk and fund manager ability indicators. Considering the strong correlation of indicators in the dimension, principal component analysis can effectively reduce the dimension of indicators with strong correlation on the basis of retaining the original information. The comprehensive score model based on principal component analysis calculates the score of each fund and sorts it, which is an effective method to evaluate the performance of the fund.

5.1. Introduction to Principal Component Analysis

Principal component analysis starts from multiple statistical indicators, uses the principles and methods of statistical analysis, extracts several unrelated comprehensive indicators, retains a large amount of information provided by the original indicators, and plays a role in dimension reduction. In the principal component analysis method, first of all, the characteristic value and characteristic vector should be calculated according to the sample data and the correlation coefficient matrix $U_j=(U_{1j},U_{2j},\cdots,U_{mj})$, the corresponding main component is $F_i=x_jU_j=\sum_{k=1}^{m}x_{ik}U_{kj}$ The contribution rate of variance of the k-th principal component is $v_k=\lambda_j/\sum_{j=1}^{m}\lambda_j$. The score of the evaluated sample is calculated, and the comprehensive score is calculated by taking the variance contribution rate of each principal component as the weight of the principal component. The weight of the k-th principal component is $w_k=\lambda_k/\sum_{j=1}^{p}\lambda_j$, and the final factor score is $z_i=\sum_{k=1}^{p}x_{ik}\times w_k$.

5.2. Performance Evaluation of Green Funds Based on Principal Component Analysis

According to the previous analysis, this paper introduces three indicators of style drift and stock selection timing into the green fund performance evaluation system.

Based on principal component analysis, this paper will build a green fund performance evaluation system without considering stock selection timing ability and considering stock selection ability respectively. In addition to the three indicators of measuring style drift ability and stock selection timing, it also selects seven indicators: sharp ratio, Jensen index, Treynor index, average rate of return, growth rate of compound net worth, beta and standard deviation of return.

DOI: 10.54254/2754-1169/57/20230528

5.2.1. Consider the Evaluation System of Stock Selection and Timing Ability

Considering the style drift of green funds and the timing ability of green fund managers, the cumulative contribution rate of the four principal components extracted by principal component analysis is 94.74%, which better describes the impact of the green fund performance of the chess team and the overall impact on the green fund performance. From the principal component score coefficient matrix, we can see that principal component 1 mainly describes the characteristics of green fund returns; Principal component 2 describes the characteristics of green fund risk; Principal component 3 describes the characteristics of green fund style drift; Principal component 4 describes the timing characteristics of green funds.

Table 5: Principal Component Score Considering the New Indicators.

	PC1	PC2	PC3	PC4
Sharpe	0.168	-0.124	0.102	-0.073
SEL	0.16	0.073	-0.3	-0.139
SDS	-0.008	0.256	0.44	-0.894
Jensen	0.163	-0.013	0.131	0.224
SDY	0.046	0.427	0.214	0.332
Beta	0.05	0.436	-0.038	0.367
TIM	-0.057	-0.191	0.69	0.409
ARR	0.176	-0.053	0.081	-0.005
Treynor	0.171	-0.104	0.097	-0.048
NWGR	0.175	-0.068	0.076	-0.059

According to the variance contribution rate, the weight of each principal component can be obtained (see table 5), and finally the comprehensive performance score model can be obtained:

$$F = 0.590F1 + 0.200F2 + 0.124F3 + 0.081F4 \quad (10)$$

5.2.2. Evaluation System Without Considering the Ability of Stock Selection and Timing

Without considering the style drift of green funds and the timing ability of green fund managers, the cumulative contribution rate of the two principal components extracted by principal component analysis is 92.58%, which better describes the impact on the performance of green funds and the overall impact on the performance of green funds. From the principal component score coefficient matrix, we can see that principal component 1 mainly describes the characteristics of green fund returns; Principal component 2 mainly describes the risk characteristics of green funds.

Table 6: Principal Component Score Without Considering the New Indicators.

	PC1	PC2
Sharpe	0.201	-0.118
Treynor	0.204	-0.093
Beta	0.048	0.53
NWGR	0.206	-0.056
ARR	0.207	-0.032
SDY	0.051	0.53
Jensen	0.192	0.041

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According to the variance contribution rate, the weight of each principal component can be obtained (see table 6), and finally the comprehensive performance score model can be obtained:

$$F = 0.740F1 + 0.261F2 \quad (11)$$

5.2.3. Performance Evaluation of Green Fund

Based on the industry of two green fund evaluation systems under the principal component analysis method, this paper selects 100 stocks or partial stock hybrid active management green funds, calculates and sorts the performance scores of the selected green funds under the two systems respectively. The top 20% of the green funds are rated as five star green funds, and the scores of 20% to 40% are four star green funds, and so on. In the wind green fund evaluation index system, for stock and partial stock hybrid green funds, the evaluation index includes three dimensions: the risk adjusted return ability of green funds, the portfolio adjustment ability of green fund managers and the assets and changes of green fund companies. This paper compares the rating results of two green fund evaluation systems based on principal component analysis with wind rating results to further analyze the performance of green funds. Table 7 lists some results of two green fund performance evaluation systems. It can be seen that the correlation between the performance evaluation results considering industry allocation ability and wind green fund rating is 0.816, while the correlation between the performance evaluation results without industry allocation ability and green fund rating is 0.790. The introduction of industry allocation ability measurement indicators further improves the application of principal component analysis in the field of green fund performance evaluation. The evaluation results show that style drift, stock selection and timing indicators have a significant impact on the evaluation results of green funds, and it is of necessary practical significance to include industry allocation indicators in the evaluation indicators.

Table 7: Green Fund Evaluation Results.

Fund Code	Wind Rating	Score without considering indicators	Rating without considering indicators	Score considering indicators	Rating considering indicators	Rating change	Compared to Wind Rating
001985.OF	4	0.491	5	0.345	5	0	1
340007.OF	4	0.430	5	0.288	5	0	1
161028.SZ	4	0.519	5	0.336	5	0	1
540008.OF	4	0.624	5	0.338	5	0	1
398051.OF	1	-0.518	1	-0.342	2	1	1
160611.SZ	5	0.266	4	0.145	4	0	-1
100056.OF	2	-0.505	1	-0.431	1	0	-1
163409.SZ	5	0.071	4	-0.239	2	-2	-3
160225.SZ	5	-0.508	1	-0.301	2	1	-3
163803.OF	5	-0.571	1	-0.547	1	0	-4

6. Conclusion

Starting from the factors affecting the performance of green funds, this paper introduces style drift indicators, green fund managers' timing ability and stock selection ability indicators to measure the style drift and stock selection timing ability of green funds actively managed by stocks or partial stocks, and analyzes their impact on the performance of green funds. Style and stock selection timing indicators are introduced into the performance evaluation of green funds.

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This paper constructs a panel fixed effect model to empirically analyze the style drift of open partial equity and hybrid green funds in 2018-2022 and the impact of stock selection timing indicators on performance. The research shows that style drift has a negative impact on green fund performance, fund managers' stock selection ability has a significant positive impact on Performance, and fund managers' timing ability has a significant negative impact on performance.

Based on the results of empirical analysis, the principal component analysis method is used to construct a green fund performance evaluation system considering style drift and stock selection timing indicators. Determine the weight of principal components to obtain the comprehensive score model of green fund performance evaluation.

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