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# How can ESG funds improve their performance? Based on the DEA-Malmquist productivity index and fsQCA method

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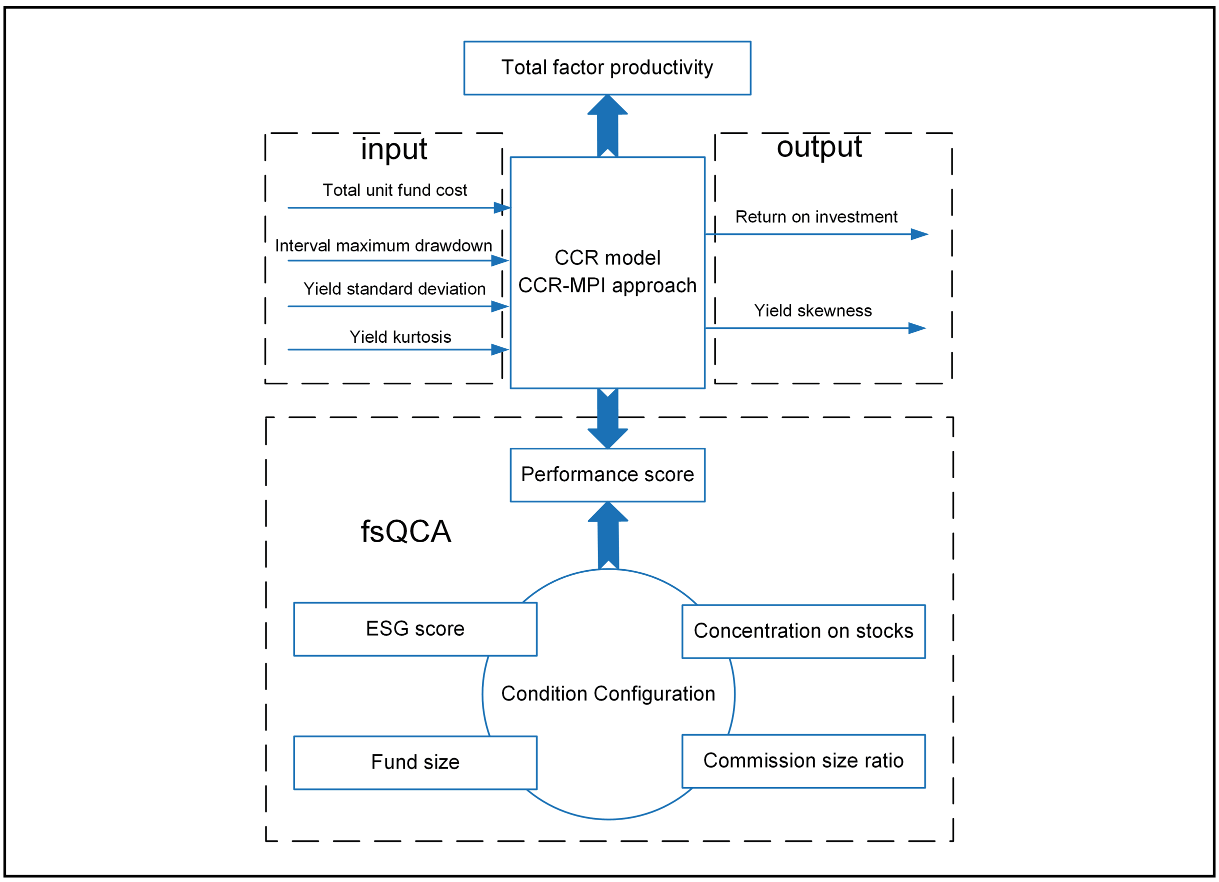
## Graphical abstract




*Technology roadmap for this paper.*

## Public summary

- This study uses the DEA-Malmquist productivity index approach to evaluate ESG fund performance from perspectives of static and dynamic.
- Considering investors' utility preferences, this study incorporates the higher order moments of fund returns into the evaluation system.
- This study uses the fsQCA method to explore the improvement paths of ESG fund performance.

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**Abstract:** In China, ESG funds are still in the early stage of development, and how to improve their performance level has become an urgent problem. Based on 26 ESG funds in 2018–2021, we use the DEA-Malmquist productivity index method to evaluate the performance of ESG funds at two levels, static and dynamic, and apply the fsQCA approach to explore the performance improvement path of ESG funds. Overall, ESG funds perform well, but there are significant differences among them. The total factor productivity of ESG funds shows a decreasing trend during the study period. There are three paths to improve the performance of ESG funds. The 1st path is to maintain a low concentration of holdings and reduce the frequency of fund position adjustments based on increasing fund size. The 2nd path is to diversify into stocks with high ESG scores based on increasing fund size. The 3rd path is to hold stocks with high ESG scores for a long time based on increasing fund size. Concerning the results of the empirical analysis, it proposes to improve the ESG rating system, broaden the market scale of ESG funds at a steady gait, and gradually optimize fund managers' investment strategies.

**Keywords:** ESG funds; DEA-Malmquist productivity index method; fuzzy set qualitative comparative analysis (fsQCA); performance improvement path

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## 1 Introduction

In 2006, the UN Principles for Responsible Investment (PRI) report put forward the ESG (environmental, social, and governance) investment concept for the first time. This investment concept refers to paying attention to environmental, social and corporate governance in the investment process. Since then, more investors have incorporated ESG criteria into their investment decisions to achieve long-term, stable returns[1–3].

Presently, domestic public institutions are accelerating the layout of various ESG fund products and promoting ESG investment practices in China. With the rapid development of ESG funds, the performance of various ESG funds is uneven. Investors want to select ESG funds with better investment performance. Fund managers want to identify what paths can be taken to effectively improve ESG fund performance. In view of this, it is important to evaluate the performance of ESG funds and research the path of ESG fund performance improvement.

Data envelopment analysis (DEA) is a nonparametric relative efficiency evaluation method based on input-output analysis[4]. In this paper, referring to the research of Guo et al.[5] on the higher-order moments of fund returns, we use various indicators in input-output and apply the CCR model to evaluate ESG fund performance. Based on the static analysis, the Malmquist productivity index conducts a dynamic analysis of ESG fund performance.

Previously, scholars studied the factors influencing the performance of securities investment funds using regression models, but a combination of factors often governs fund performance, and there are more obvious interaction effects between variables. Therefore, we use the fuzzy set qualitative comparative analysis (fsQCA) approach to explore the paths of action to enhance the performance of ESG funds. QCA is a set-theoretic group state analysis method based on Boolean algebra that can holistically explore multiple concurrent causally induced complex problems[6].

The rest of this paper is organized as follows. Section 2 reviews the related literature. Section 3 introduces the methodology and sample, index and variable selection. Section 4 is performance measurement, and we use the DEA-Malmquist productivity index method to evaluate ESG fund performance in static and dynamic terms and then use the fsQCA method to explore the path of ESG fund performance improvement. Section 5 are conclusions and recommendations.

## 2 Literature review

### 2.1 ESG investments

In recent years, ESG investment in China has emerged rapidly, but it is still nascent. Wang and Li[7] argued that in terms of ESG funds, there was a trend of generalization and uneven development of various themes. ESG investment concepts need to be integrated and deepened. Jagannathan et al.[8] found that fund managers can effectively reduce portfolio risk by considering environmental, social and governance factors in the investment process. Ma[9] found that the lower the ESG score of a listed company, the higher its investment risk. Mohanty et al.[10] found that companies with better ESG performance are more competitive than their peers. Pedersen et al.[11] argued that ESG scores of stocks can provide information on company fundamentals and can influence investor preferences. Díaz et al.[12] constructed the ESG factor as the difference in returns between firms in the top quartile of ESG ratings and firms in the bottom quartile of ESG ratings and found that ESG ratings effectively explain the variability in returns obtained from investing in different sectors during the COVID-19 pandemic.

### 2.2 Fund performance evaluation

The research on fund performance evaluation methods can be traced back to the 1950s, and after four stages of in-depth research, the evaluation methods have become richer and more complete. Markowitz[13] pioneered the construction of the mean-variance model. Sharpe[14] proposed the classical capital asset pricing model based on it. Then Treynor[15], Sharpe[16], and Jensen[17] proposed the Treynor index, Sharpe ratio, and Jensen index to measure the relationship between risk and return of investment portfolios, respectively. Ross[18] proposed the ATP model based on risk-free arbitrage theory, and on this basis, Fama and French[19] proposed a three-factor model, Carhart[20] proposed a four-factor model, and then Fama and French[21] further proposed a five-factor model.

The models introduced in the first two phases mostly consider external factors such as market returns, but internal factors such as the stock selection and timing ability of fund managers also affect the performance level of funds to a large extent. Treynor and Mazuy[22] first proposed the T-M model to study the relationship between fund managers' stock picking and timing ability and the portfolio's risk-return. Later, Henriksson and Merton[23] added dummy variables to the T-M model to form the H-M model. Then Chang and Lewellen[24] added the difference between the beta of bull and bear markets to construct the C-L model. In recent years, various comprehensive evaluation models have been used to evaluate fund performance from a deeper and more diverse perspective. For example, Wang and Huang[25] constructed a mutual fund performance evaluation model using a fast adaptive neural network classifier (FANNC) and compared its performance in classification and prediction with a back propagation neural network (BPN) model. However, the DEA model is the most developed and used among them. Chen and Li[26] first applied the DEA model in domestic fund performance evaluation research. However, it only considered a single input-output indicator, and then Ding et al.[27] used a DEA model with multiple input and output indicators.

### 2.3 Factors affecting fund performance

Many scholars in China and abroad have analyzed and studied the factors influencing fund performance using various methods. Elton et al.[28] used the CAPM model to calculate a fund's excess return. The regression analysis found that the fund turnover rate negatively affects fund performance. Delva and Olson[29] found that the fund fee rate is also negatively related to fund performance. Levis et al.[30] used U.S. securities investment funds as a sample and found an inverted U-shaped relationship between fund size and fund performance. Kacperczyk et al.[31] found that funds with high investment sector concentration performed better than those with sector diversification by examining the investment sector concentration of U.S. equity funds. Kong et al.[32] used the same approach to explore the effect of industry concentration on fund performance based on the study of Ref. [31], but obtained the opposite conclusion that diversification is effective in improving fund performance.

In summary, domestic and foreign scholars have rich and increasingly complete research on the performance evaluation methods of securities investment funds. However, there are still areas for improvement in the performance evaluation research of ESG funds. In this paper, we adopt the DEA-Malmquist productivity index method to evaluate the performance of ESG funds from both static and dynamic levels. In the past, scholars have only used single or few factor indicators to explore fund performance without considering the impact of the combination of factors on fund performance. Therefore, we use the fsQCA method to explore the ESG fund performance improvement path based on the grouping perspective.

## 3 Methodology

### 3.1 Sample selection

ESG funds are mainly divided into "pure ESG funds" and "pan ESG funds". In the past three years, ESG investment in China has emerged rapidly, especially the number of pure ESG funds has risen significantly compared with the past. More than 40% of new ESG funds are pure ESG funds. However, China is still dominated by pan ESG fund products, accounting for more than 90%. Many pan ESG funds have been established for several years and have experienced a complete market of low shocks, sharp declines, rapid rises, and high divergences in the securities market, which are more meaningful for research.

In this paper, we screen funds established before January 1, 2018 from the Wind database with the keywords "low carbon", "environmental protection", "new energy", "green", "social responsibility", "beautiful China", and "sustainable development" as themes and obtain a total of 26 funds after excluding passive index funds and QDII hybrid funds. Considering the small number of ESG fund offerings before 2018 and the fact that data for some variables are only disclosed in fund annual reports. Aiming to cover a broader phase of ESG fund development, we selected the study period ranging from January 1, 2018 to December 31, 2021.

### 3.2 Data envelopment analysis

In this paper, we use the input-oriented CCR model and treat each sample fund as a decision making unit ($\mathrm{DMU}_j$). If each ESG fund uses $k$ inputs $x=(x_1,\cdots,x_k)\in \mathrm{R}_+^K$, we can obtain $m$ outputs $y=(y_1,\cdots,y_m)\in \mathrm{R}_+^M$, and introduce the slack variables $s^+, s^- \geqslant 0$. The CCR model can be constructed as


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follows:

$$
\begin{aligned}
&\operatorname{Min}\theta \\
&\text{s.t. } \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{i0},\ i = 1,\cdots,k; \\
&\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{r0},\ r = 1,\cdots,m; \\
&\lambda_j \geqslant 0; \\
&s^+ \geqslant 0,\ \ s^- \geqslant 0.
\end{aligned} \tag{1}
$$

Since the CCR model can only statically analyze the performance value of each fund in each year and cannot longitudinally analyze the change in the performance value of funds from year to year, we combine the Malmquist productivity index to analyze the performance level of ESG funds dynamically. The productivity index is also known as total factor productivity change index (TFPCH). It can be decomposed as follows:

$$
\begin{aligned}
&\mathrm{TFPCH}(x^{t+1}, y^{t+1}, x^t, y^t) = \\
&\left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}} = \\
&\left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}} \times \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} = \\
&\mathrm{TECH} \times \mathrm{EFFCH},
\end{aligned} \tag{2}
$$

where $(X^{t+1}, Y^{t+1})$ and $(X^t, Y^t)$ denote the input-output vectors of the fund in year $t+1$ and year $t$, respectively. From Eq. (2), TFP is decomposed into the efficiency change index (EFFCH) and technical progress efficiency change index (TECHCH). Regarding the technical progress efficiency change index, it is the innovation and breakthrough of the fund in terms of management operations method and investment philosophy.

$$
\mathrm{EFFCH} = \mathrm{PECH} \times \mathrm{SECH}. \tag{3}
$$

The EFFCH can be decomposed into a pure technical efficiency change index (PECH) and a scale efficiency change index (SECH), with the PECH indicating the fund's ability to convert risk into reward and the SECH indicating the level of risk to which the fund is exposed.

### 3.3 DEA input and output index selection

A fund's operation and management process can be viewed as an activity where a fund manager raises funds for active investment, assumes the corresponding market risk, and obtains a portion of the return. Fund performance evaluation aims to assess the efficiency of the fund's overall operation from the investor's perspective. Based on this purpose, we select the following input and output indicators.

Total unit fund cost ($X_1$). We choose total unit fund expenses as the index to measure fund expense costs. The fund expense cost mainly includes the fund's management fee, transaction fee, and custodian fee.

$$
\mathrm{Unit} = \frac{\mathrm{Total}}{(\mathrm{Initial} + \mathrm{End})/2}, \tag{4}
$$

where Unit is the total unit fund cost, Total is the total expenses for the period, Initial is the initial fund shares and End is the end fund shares. In particular, the total expenses for the period are taken from the fund's annual income statement.

Interval maximum drawdown ($X_2$). The fund's maximum drawdown is the magnitude of fluctuation between the highest and lowest point of the fund's net worth during the interval period. The smaller the retracement figure, the better the fund manager's ability to respond to changes in market conditions and control risk.

Yield standard deviation ($X_3$). We use the standard deviation of daily unit fund ANAV returns during the evaluation period to measure the volatility of fund returns. The formula for calculating the daily unit fund ANAV return is as follows:

$$
R_{jk} = \frac{\mathrm{ANAV}_{jk} - \mathrm{ANAV}_{j(k-1)}}{\mathrm{ANAV}_{j(k-1)}}, \tag{5}
$$

$R_{jk}$ denotes the return of the $j$th fund on day $k$, $\mathrm{ANAV}_{jk}$ denotes the compounded net unit value of the $j$th fund on day $k$, and $\mathrm{ANAV}_{j(k-1)}$ denotes the compounded net unit value of the $j$th fund on day $k-1$. The formula for calculating the standard deviation of the yield is as follows:

$$
\sigma_{jt}^2 = \frac{\sum\left(R_{jk} - \overline{R_{jt}}\right)^2}{n-1}, \tag{6}
$$

where $n$ denotes the number of days included in the $t$th period.

Yield kurtosis ($X_4$). Kurtosis describes the steepness of the distribution pattern of fund return data. If the kurtosis of a fund's return is smaller, it indicates that the fund's return is mainly distributed around the mean. Conversely, the probability of extreme variation is high, which is undesirable for investors. Therefore, we use the kurtosis of daily fund ANAV returns per unit during the evaluation period to measure the stability of returns. The formula for calculating the kurtosis of yield is as follows:

$$
K = E\left[\left(\frac{R_j - E(R_j)}{\sigma_J}\right)^4\right] = \frac{1}{n-1}\sum\left(R_j - \bar{R}_j\right)^4 / \sigma_j^4. \tag{7}
$$

Return on investment ($Y_1$). We choose the cumulative daily return as an indicator of the fund's return level. The formula for calculating the cumulative daily return is as follows:

$$
R_{jt} = \prod_{k=1}^{n}(1 + R_{jk}) - 1. \tag{8}
$$

Yield skewness ($Y_2$). Skewness describes the symmetry of the fund return data distribution. If the skewness of fund returns is smaller, it indicates that the fund is more likely to have higher than expected returns and more likely to earn more excess returns. Therefore, we use the skewness of the daily fund ANAV return per unit during the evaluation period to measure the number of excess returns obtained. The formula for calculating the skewness of the yield is as follows:

$$
S = E\left[\left(\frac{R_j - E(R_j)}{\sigma_J}\right)^3\right] = \frac{1}{n-1}\sum\left(R_j - \bar{R}_j\right)^3 / \sigma_j^3. \tag{9}
$$



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Since the DEA model requires the input and output index to take non-negative values, the following treatment is made for negative values in this paper:

$$X_{ij}^{'} = 0.1 + \frac{X_{ij} - \min X_{ij}}{(\max X_{ij} - \min X_{ij}) \times 0.9}, \tag{10}$$

where $X_{ij}$ is the original data and $X_{ij}^{'}$ is the transformed data. This transformation shifts all data to the $(0,1]$ interval, which does not affect the relative validity of the decision units and does not change the evaluation results.

### 3.4 Qualitative comparative analysis

In this paper, the number of samples selected for the study of the ESG fund performance level improvement path is only 26, which is relatively low, and the performance of ESG funds is often constrained by a joint effort of various factors. There is a more obvious interaction effect between variables, so it is not suitable for regression analysis. However, the QCA method chosen in this paper is particularly advantageous in small-sample research. The QCA method mainly considers the interaction between the elements without the problem of "endogeneity". It treats the cases as a grouping of conditional elements, which can help draw the path of influencing factors on the level of ESG fund performance. Given the continuous nature of the condition and outcome variables selected for this paper, the fsQCA method was adopted to analyze the sample data.

### 3.5 QCA variable selection

We choose 26 ESG fund performance scores in 2021 as the outcome variable for the QCA. The year 2021 is chosen for the analysis because, on the one hand, ESG funds have proliferated in recent years. In terms of the size of the sample funds from 2018 to 2021, the overall size in 2021 nearly doubled compared to 2020, and the development is becoming more mature and more relevant to the current market. On the other hand, driven by industry, the performance level of ESG funds improved significantly in 2019–2020. However, there is a high level of divergence in performance starting in 2021, with some funds scoring very low. This divergence is more conducive to obtaining the optimal path of improvement.

In the analysis of medium samples, four to six conditional variables are usually selected. Drawing on the conditional variable selection method adopted by Ref. [33], we adopt a "theoretical perspective" approach to the selection of conditional variables, selecting ESG score, fund size, concentration on stocks, and commission size ratio as conditional variables.

ESG score. This variable measures the fund manager's ESG rating preference for the stocks it holds.

Fund size. This variable measures the total net asset value of the fund.

Concentration on stocks. This variable measures the proportion of the top 10 longest positions to the market value of stocks. A higher ratio indicates a more concentrated holding. A lower ratio indicates more diversified holdings.

Commission size ratio. This variable indicates the ratio of total commissions paid during the fund's annual reporting period to the fund's size. A higher ratio indicates that the fund manager has moved positions more frequently.

## 4 Empirical analysis

### 4.1 Static analysis of ESG fund performance

Based on the input-oriented CCR model, we use Deap2.1 software to derive the performance scores of 26 ESG funds in 2018–2021, and the results are described in Table 1.

Table 1 gives the performance scores for each sample fund from 2018–2021. The mean performance scores for each year are 0.785, 0.781, 0.818, and 0.729. The performance scores are generally maintained at a high level with low volatility, but the mean score in 2021 has a slight decrease compared to the previous three years. There are two main reasons for this. On the one hand, the continuous release of domestic policy dividends, along with the rapid development of the capital market, made ESG funds develop rapidly in 2018–2020. The net value level of each ESG fund has been significantly improved, thus attracting many investors and significantly increasing fund size. However, individual fund managers do not adjust their investment strategies in time, resulting in a

**Table 1.** 2018–2021 ESG fund performance evaluation results.

| DMU | Fund code | Performance score | | | |
|---|---|---|---|---|---|
| | | 2018 | 2019 | 2020 | 2021 |
| 1 | 000977 | 0.743 | 0.900 | 1.000 | 0.511 |
| 2 | 004640 | 0.801 | 0.725 | 1.000 | 0.603 |
| 3 | 001166 | 1.000 | 0.679 | 1.000 | 1.000 |
| 4 | 000409 | 0.651 | 0.591 | 0.992 | 0.628 |
| 5 | 000696 | 0.169 | 0.295 | 1.000 | 0.878 |
| 6 | 001975 | 0.818 | 1.000 | 1.000 | 1.000 |
| 7 | 002259 | 1.000 | 0.923 | 0.738 | 0.247 |
| 8 | 530019 | 1.000 | 0.616 | 0.729 | 0.217 |
| 9 | 340007 | 0.906 | 0.787 | 0.600 | 0.632 |
| 10 | 470028 | 0.388 | 1.000 | 0.646 | 0.584 |
| 11 | 000120 | 0.817 | 0.649 | 0.732 | 0.521 |
| 12 | 000822 | 0.980 | 0.387 | 0.793 | 0.991 |
| 13 | 000663 | 0.901 | 1.000 | 0.646 | 0.719 |
| 14 | 000017 | 0.897 | 1.000 | 0.710 | 0.164 |
| 15 | 163409 | 0.810 | 1.000 | 0.630 | 0.729 |
| 16 | 350002 | 0.711 | 1.000 | 0.531 | 1.000 |
| 17 | 100056 | 0.885 | 1.000 | 1.000 | 0.929 |
| 18 | 001856 | 1.000 | 1.000 | 1.000 | 0.784 |
| 19 | 001616 | 0.805 | 1.000 | 1.000 | 1.000 |
| 20 | 540008 | 0.444 | 0.773 | 0.979 | 0.983 |
| 21 | 002244 | 0.556 | 0.827 | 0.403 | 0.851 |
| 22 | 001208 | 1.000 | 0.495 | 0.722 | 1.000 |
| 23 | 001983 | 0.893 | 0.698 | 0.573 | 0.408 |
| 24 | 398051 | 0.916 | 1.000 | 1.000 | 0.737 |
| 25 | 004925 | 0.872 | 0.283 | 1.000 | 1.000 |
| 26 | 005037 | 0.446 | 0.669 | 0.837 | 0.831 |
| Mean | | 0.785 | 0.781 | 0.818 | 0.729 |


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decline in the performance of the managed funds. On the other hand, the continuous and rapid growth of fund performance in 2018–2020 has increased the risk of matching fund valuation with performance in the short term. Some fund managers over relied on $\beta$ returns in managing the fund and neglected $\alpha$ returns in sector investment, resulting in a decline in the risk-return ratio of the fund, which led to a decline in fund performance.

Specifically, there are 5, 10, 10, and 6 funds in the efficiency frontier for each year, respectively. Although the average value of the performance score remains approximately 0.8% for each year, the performance level varies significantly among funds, with few funds at the efficiency frontier and most having more room for improvement. In terms of performance across years, most funds show little change in fund performance, showing a slight regression or improvement. With the continuous promotion of China's "double carbon" goal and the popularization of social responsibility, the ESG concept has been highly respected in recent years. There is a clear trend for financial institutions to develop ESG-themed funds in line with the general trend. In addition, there are a few funds with unsatisfactory improvement results, resulting in a decline in performance. Therefore, in the next phase of improvement work, each fund manager should combine their actual situation and make corresponding adjustments in time to obtain better return-risk allocation according to the changes in market conditions.

## 4.2 Dynamic analysis of ESG fund performance

Following the indicator system and model in the previous section, based on the panel data of 26 ESG funds from 2018–2021, we calculate the average annual change in the Malmquist productivity index of the sample funds by Deap2.1 software, and the results are described in Table 2.

According to Table 2, we use 2018 as the base period, and the Malmquist productivity index has an average value of 0.925. TFPCH shows a slight decline over the four years, with an average annual decline of 7.5%. However, the change in TFPCH is smaller each year. The decomposition index shows that the average value of EFFCH was 0.964 in 2018–2021, with an average annual decline of 3.6% in overall efficiency. Among them, the average value of PECH and SECH is less than one during the four years, which contributes negatively to EFFCH, indicating that the fund's ability to withstand risk and obtain returns has decreased in recent years. The average value of TECHCH is 0.959, indicating that TECHCH has decreased by 4.1% annually. While the fund's performance has improved significantly over the four years, the TECHCH has declined slightly. The possible reason is that many fund managers are relatively backward in investment philosophy and management methods and have not kept up with market development and current trends. Alternatively, they may not know enough about ESG investment itself and pursue the financial dividends of ESG investment, which leads to the phenomenon of "greenwashing" in ESG investment[34]. Over time, the short-term benefits of "greenwashing" will lead more fund managers to follow suit, affecting ESG funds' efficiency in terms of technological progress.

**Table 2.** Annual average change in the ESG fund Malmquist productivity index.

| Year | EFFCH | TECHCH | PECH | SECH | TFPCH |
|---|---|---|---|---|---|
| 2018–2019 | 0.997 | 0.848 | 1.05 | 0.949 | 0.845 |
| 2019–2020 | 1.077 | 0.983 | 1.051 | 1.025 | 1.059 |
| 2020–2021 | 0.834 | 1.058 | 0.835 | 0.999 | 0.883 |
| Mean | 0.964 | 0.959 | 0.973 | 0.991 | 0.925 |

## 4.3 ESG fund performance improvement path

### 4.3.1 Fuzzy set calibration

QCA fuzzy set analysis requires variables to be continuous affiliation scores between 0 and 1. According to the selected "anchor points" (fully affiliated, crossover point, fully unaffiliated), the variables are calibrated by converting the values into continuous affiliation scores between 0 and 1. There are some differences in the values of "anchor points" in the current empirical studies, and this paper uses the Calibrate program in the fsQCA 3.0 software, which is currently used more often. The fully affiliated "anchor points" are taken as 0.95 quantiles of the value of each variable, the crossover points are taken as 0.5 quantiles, and the fully unaffiliated "anchor points" are taken as 0.05 quantiles. The selection of "anchor points" is shown in Table 3.

### 4.3.2 QCA conditional variable necessity analysis

Before using the QCA method to analyze the combination of conditions, it is necessary to check whether the individual condition variables are necessary. Drawing on Ref. [35], we use 0.9 as the consistency threshold for testing the necessary conditions. Using fsQCA 3.0 software to analyze the necessary conditions for high-performance scores of ESG funds, the results are shown in Table 4. The consistency of every single condition is below 0.9, and there is no necessary condition.

### 4.3.3 QCA fuzzy set analysis results and interpretation

In QCA, consistency and frequency thresholds must be set to filter out groups with stronger subset relationships. Drawing on the study of Fiss[36], we set the consistency threshold to 0.8 and the PRI consistency threshold to 0.75 to reduce contradictory groups. Due to this study's small number of samples, 1 is chosen as the case frequency threshold to retain more original cases. The results of this study mainly decipher the intermediate solutions. The results are analyzed using fsQCA3.0 software, and the results are collated and detailed in Table 5.

From Table 5, three conditional combinations leading to high-performance scores for the fund are derived from the qualitative comparative analysis of fuzzy sets. Overall, the consistency of the solution is 0.877 > 0.8, and the coverage is 0.523 > 0.5, with significant results. Specific analysis is performed for each path.

**$H_1$.** Fund size * ~Concentration on stocks * ~Commission size ratio. This path suggests that regardless of the fund's ESG rating, increasing fund size, maintaining a low concentration of holdings, and minimizing the frequency of position changes will improve the fund's performance. A larger size is



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**Table 3.** QCA fuzzy set calibration “anchor points”.

| Research variable | | Anchor point | | |
|---|---|---|---|---|
| | | Fully affiliated | Crossover point | Fully unaffiliated |
| Condition variable | ESG score | 6.98 | 6.80 | 6.48 |
| | Fund size | 80.95 | 11.12 | 0.30 |
| | Concentration on stocks | 0.68 | 0.56 | 0.44 |
| | Commission size ratio | 0.61 | 0.26 | 0.09 |
| Result variable | Performance score | 1.00 | 0.76 | 0.22 |

**Table 4.** Necessity analysis of condition variables.

| Condition variable | Performance score | | Condition variable | Performance score | |
|---|---|---|---|---|---|
| | Consistency | Coverage | | Consistency | Coverage |
| ESG score | 0.630 | 0.687 | ~ESG score | 0.541 | 0.625 |
| Fund size | 0.620 | 0.771 | ~Fund size | 0.587 | 0.599 |
| Concentration on stocks | 0.540 | 0.620 | ~Concentration on stocks | 0.641 | 0.702 |
| Commission size ratio | 0.530 | 0.630 | ~Commission size ratio | 0.726 | 0.771 |

**Table 5.** QCA fuzzy set analysis results.

| Condition variable | High performance score | | |
|---|---|---|---|
| | $H_1$ | $H_2$ | $H_3$ |
| ESG score | | ● | ● |
| Fund size | ● | ● | ● |
| Concentration on stocks | ⊗ | ⊗ | |
| Commission size ratio | ⊗ | | ⊗ |
| Consistency | 0.946 | 0.881 | 0.927 |
| Raw coverage | 0.369 | 0.324 | 0.385 |
| Unique coverage | 0.091 | 0.046 | 0.108 |
| Solution coverage | | 0.877 | |
| Solution consistency | | 0.523 | |

● Core condition present. • Edge condition present. ⊗ Core condition absent. ⊗ Edge condition absent. A blank space indicates that the condition is optional. “Present or absent” is selected for all conditions when generating intermediate solutions.

the basis for a fund manager to be able to make long-term and diversified investments. On the one hand, increasing fund size helps fund managers reduce the average cost of various fixed fees. On the other hand, it reduces the fund’s liquidity risk and provides sufficient capital to respond to large redemptions by investors. A long-term and diversified investment style can effectively diversify the fund’s investment risk and minimize the fund’s retracement level, which can improve investors’ holding experience and attract more capital.

**$H_2$.** ESG score * Fund size * ~Concentration on stocks. This path indicates that under the premise of increasing fund size, actively using various strategies such as positive screening, negative screening, and ESG integration and diversifying into high ESG score stocks will improve the fund’s performance. In comparison, concentration on stocks has less impact on the path. Presently, the small fund size of domestic ESG funds restricts the development of ESG funds. Fund managers need to be more comprehensive in screening stock pools. They can only select a small number of high-quality enterprises with small market capitalization. In addition, China’s ESG investment has problems such as insufficient mandatory ESG information disclosure and an imperfect ESG rating system. Some companies use regulatory black holes to falsify data to escape regulation temporarily. If the concentration of fund holdings is too high will aggravate future fluctuations in fund net value. In contrast, diversified holdings can minimize the impact of black swan events on fund net value.

**$H_3$.** ESG score * Fund size * ~Commission size ratio. This path indicates that under the premise of increasing fund size, actively using various strategies such as positive screening, negative screening and ESG integration, holding high ESG score stocks for a long time can improve the fund’s performance. In comparison, the commission size ratio has less impact on the path. The fund manager uses a larger pool of capital to build a portfolio of high ESG scoring stocks. On the one hand, it has lower systematic risk exposure. On the other hand, it has a lower WACC than the low ESG score portfolio, which can enhance the future valuation level of the portfolio


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by reducing the discount rate of the DCF model. Therefore, high ESG score equity portfolios have a better risk-return ratio in the long run. In addition, unlike the high readability and comparability of financial information, many evaluation indicators of ESG investment need a stronger correlation with short-term financial performance. It is often difficult to see the correlation with corporate performance returns in the short term. However, it will affect corporate strategy and sustainable development in the long term. Hence, fund managers need to try to avoid frequent position transfers in ESG investments to obtain short-term returns.

#### 4.3.4 Robustness check

Based on the studies of Meuer et al.[37], using the method of increasing the consistency threshold, the results are checked for robustness, i.e., keeping the other treatments unchanged and adjusting the consistency threshold of the histological analysis from 0.8 to 0.85. Compared with the initial results, the overall consistency level is maintained at 0.88, and the high-performance score path does not change, indicating that the results of this study's analysis are robust.

## 5 Conclusions

### 5.1 Findings

In this paper, we select a sample of 26 ESG funds from 2018–2021 for the empirical study. Specifically, we use the DEA-Malmquist productivity index method to evaluate the performance of ESG funds at two levels, static and dynamic, respectively, and further use the fsQCA method to explore the performance improvement path of ESG funds. The specific conclusions obtained are as follows:

First, from the results of the static analysis of ESG fund performance evaluation, it can be concluded that the average value of the performance score for each year from 2018 to 2021 is maintained at approximately 0.8, which is a high level. However, the performance of each fund is seriously divided, and some funds have large differences in performance scores or always maintain a low level from year to year, which has a large progress space. Second, from the results of the dynamic analysis of ESG fund performance evaluation, it can be concluded that the overall total factor productivity shows a small decreasing trend during the four years. Disaggregated, the efficiency change index and the technical progress efficiency change index mainly influence each fund's total factor productivity. Third, from the group analysis of the performance evaluation results of ESG funds, three paths can effectively improve the performance level of ESG funds. The 1st path is to maintain a low concentration of holdings and reduce the frequency of fund position adjustments based on increasing fund size. The 2nd path is to diversify into stocks with high ESG scores based on increasing fund size. The 3rd path is to hold stocks with high ESG scores for a long time based on increasing fund size.

### 5.2 Policy implications

Based on the above findings, the following recommendations are provided:

First, through policy leadership, we will continue to improve the ESG rating system and maintain its standardization and diversity. After continuous in-depth research and analysis, the domestic Wind ESG rating now officially covers all A shares. However, compared to foreign rating systems, the ESG rating system is young, especially for funds. It needs to be improved, so it requires a national policy to guide institutions in building an ESG fund rating system compatible with the rules and goals of China's development. On the one hand, in the construction of the ESG fund rating system, we can refer to the dominant global ESG fund rating methods, learn from advanced experience and numeracy methods, and construct an assessment system that is consistent with international practices and standards while also reflecting Chinese market characteristics in terms of indicator design. On the other hand, in addition to risk assessment and ESG evaluation of products, we can consider presenting the results of the product score from a larger number of aspects, such as scoring the ESG performance of the issuer and the impact of the issuer's credit rating on the ESG fund evaluation results.

Second, the ESG fund market scale should be steadily expanded. The premise of the three paths derived in the paper is to increase the size of ESG fun, showing their importance. In the case of mainstream media, they should popularize the ESG investment concept to investors through multiple angles, strengthening investors' understanding of ESG and sustainability, increasing the social focus of ESG funds, enhancing investor awareness of long-term investment, and guiding the flow of market capital into the ESG industry. Fund companies should actively promote ESG fund variety and innovation to meet the diverse investment needs of investors to attract many dispersed funds in and out of the field and expand the scale of the fund. Fund managers should raise awareness of risk control, select high-quality assets for allocation and strive to create products with a high risk-to-return ratio to reward investors so that ESG investment can be recognized by investors and the market and help them to form a long-term investment and value group, forming a consensus on ESG investment in the financial market.

Third, fund managers should focus on raising awareness of ESG investments and progressively optimizing their investment strategies. Combining the conclusions of the 2nd path and 3rd path, we provide the following suggestions. First, fund managers need to strengthen their stock selection ability. When screening investment targets, fund managers should pay more attention to the changes in ratings of international or domestic mainstream institutions on investment targets, prioritizing targets with high institutional ratings and combining the fundamentals of the underlying assets, PE & PB, and industry growth with further screening. Second, fund managers need to make a good investment portfolio and try to achieve diversification of stock holdings and industry diversification. Finally, fund managers should insist on holding the screened-out quality portfolio for a long time to avoid frequent operations and chasing the ups and downs to the greatest extent possible. However, it is worth noting that holding for a long time does not mean holding all the time. Tracking each underlying asset pool for a long time, setting reasonable stop-loss and stop-gain lines, and making corresponding adjustments


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according to market changes can lead to more robust returns.

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## Conflict of interest

The authors declare that they have no conflict of interest.

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