Development of a Carbon Financial Performance Assessment Model for the Power Generation Industry

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Abstract. In the face of global warming, sustainable development has become a universal choice for all countries in the world. China has put forward the goal of "double carbon" and promoted the low-carbon transformation of traditional energy enterprises, which has put forward higher requirements for their energy saving and emission reduction. In this context, this paper presents a comprehensive analysis of the challenges and opportunities of carbon finance development at the micro level. And for power generation enterprises, a financial performance evaluation system is constructed from three dimensions: economic, social and environmental. The data of 18 indicators of 32 listed companies in power generation industry are selected as samples, and the mathematical model is assigned by CRITIC method, and the comprehensive financial performance evaluation of the above companies is carried out by TOPSIS method. It provides theoretical support and referential decisions for low-carbon transformation of power generation enterprises, with a view to improving the comprehensive efficiency of enterprises.

Keywords: Carbon accounting; Financial performance evaluation; CRITIC; TOPSIS

1. Introduction

In recent years, global warming caused by greenhouse gas emissions has posed a great threat to human survival and development. According to the latest analysis data from the International Energy Agency (IEA), global energy-related carbon dioxide emissions increased by 6% to 36.3 billion tons in 2021, breaking the record. Confronted with the challenge of global warming, China, as a responsible country, will strive to achieve carbon peak by 2030 and carbon neutrality by 2060. The proposed "double carbon" target will remarkably promote China's enterprises to undergo low-carbon transition and green development strategies more proactively [1].

The Carbon Emissions Ranking of China's Listed Companies (2021) shows that traditional energy industries such as electricity, coal, and oil account for the majority of China's total carbon emissions. In addition, the power industry, as the first industry to be included in the carbon trading pilot market, has a pivotal influence on the development of the national carbon market. The traditional financial performance assessment system, which focuses on the pursuit of maximizing economic benefits, can no longer meet the needs of sustainable development. Promoting further development of the theoretical framework of carbon finance is both a priority for promoting sustainable economic and social development and a significant path to achieve the goal of carbon neutrality. Under this circumstance, it is important to construct a new financial performance evaluation system for the power industry that takes economic, social and ecological benefits into account and meets the requirements of sustainable development, so as to effectively convey information to both internal and external enterprises.

Based on the traditional financial performance evaluation system, this paper adds two perspectives of environmental protection and social responsibility to process a more systematic and comprehensive assessment of the financial performance of electric power enterprises, in order to improve the comprehensive benefits of enterprises and provide suggestions for the low-carbon transformation of traditional energy enterprises.

2. Literature review

2.1. Carbon accounting

Carbon accounting is a product of low carbon economy, which is a management activity to account for the accounting matters and elements involved in the process and results of carbon activities of enterprises or other organizations [2].

In recent years, with the development of carbon trading market, the construction of carbon accounting system and how to account and disclose the management and trading of carbon assets are the focus of discussion among scholars at home and abroad. Chen and Song (2022) examined the carbon emissions trading mechanism and discussed the basis for accounting recognition and measurement of carbon emissions trading in the context of the new accounting standards [3]. Datt et al.(2019) and Luo (2019) respectively examined the factors associated with carbon disclosure from the perspective of corporate performance and social institutions[4][5]. However, scholars generally point out that the accounting rules of carbon emission rights still need to be unified [6].

Accordingly, scholars have engaged in heated discussions to integrate sustainability into corporate financial management objectives, resulting in the research direction of carbon finance [7]. Lee (2015) and Wang et al (2021) conducted an in-depth discussion on the correlation between carbon performance and corporate financial performance [8][9]. And at the level of corporate governance, Lu et al (2017). pointed out that enterprises should establish a carbon finance strategy system and management system in order to effectively carry out green investment and financing management and capital operation management related to carbon emission rights assets in their finance work [10]. Meanwhile Qian et al. (2018) emphasized that practitioners should improve their carbon financial management and disclosure through audit and control tools [11].

Overall, most of the carbon accounting research at this stage focuses on carbon accounting system while the research on carbon finance is mainly focused on the relationship between corporate carbon performance and financial performance and the prevention of carbon finance risks. Scholars have achieved certain results in cognitive research areas such as economic effects and management strategies, but the mechanism of carbon information as an important forward-looking environmental information affecting corporate financial performance is still unclear.

2.2. Financial performance evaluation system

Research on financial performance evaluation system in recent years has mainly focused on the construction and application of financial performance evaluation system for certain types of enterprises or organizations, and different research methods have been innovatively adopted.

Yang (2022) constructed an improved DuPont analysis system with equity operating net present ratio as the core indicator [12]. Liu et al. (2021) constructed an entropy weighted RSR method of financial performance assessment model and established a related performance evaluation index system [13]. However, such studies did not combine the impact of low-carbon economy on the objectives of financial performance with the economic, social and ecological benefits.

Tu et al. (2022) emphasizes that under the "double carbon goal", carbon accounting system constitutes a prerequisite for financial and accounting supervision to promote green and low-carbon development so improving carbon accounting and reporting rules of enterprises is the first task [14]. The carbon financial index is based on the more mature carbon accounting information, which will highly summarize the carbon activities of enterprises from the perspective of financial accounting and deliver effective information about sustainability of enterprises to investors. In addition, a comprehensive set of financial indicators can improve the comparability of information among enterprises, provide a point of reference for national control, and provide a reference for other industries, so it is of high research value.

3. Methodology

The current methods of evaluating the financial performance of Chinese enterprises can be summarized into two categories: one is the single-indicator evaluation method, including the return on net assets (ROE) method, economic value added (EVA) method, etc.; the other is the multiple-indicator evaluation method, including DEA method, hierarchical analysis method, etc. Although each of these methods has its own strengths, they all have some shortcomings. Return on net assets (ROE) does not fully reflect the use of corporate funds; economic value added (EVA) is not suitable for comprehensive evaluation and comparative analysis of corporate performance. And among the multiple indicator evaluation methods, the DEA method is deficient in the analysis of merit ranking; the hierarchical analysis method is influenced by individual subjective factors, and the results are more subjective. Therefore, in this paper, after considering the above methods, the CRITI-TOPSIS method is selected to analyze the indicators, which integrates the subjectivity and objectivity of evaluation indicators and reduces the interference of subjective factors with the extreme value of individual data weights. The financial performance evaluation results are quantified to form a more complete set of carbon financial performance evaluation model.

CRITIC assignment method is a weighting method based on the comparative strength and conflicting nature of evaluation indicators. The attribute weights are assigned by comprehensively measuring the amount of information contained in the attributes based on the variability within a single attribute and the correlation between multiple attributes, which largely avoids problems such as distortion of weights caused by considering only the degree of confusion among indicators. TOPSIS method is a method for ranking the evaluation objects in terms of their merits. This method is used to make decisions by constructing positive and negative ideal solutions of multi-indicator problems. TOPSIS method can reflect the overall situation of the sample in a centralized manner and conduct comprehensive analysis, which has universal applicability. However, this method requires quantitative data of evaluation indicators and is influenced by the dispersion of indicators. Therefore, this paper combines it with the CRITIC method to reduce the above deficiencies and make it applicable to carbon financial performance assessment.

4. Model Construction

Based on the previous analysis, this paper constructs a carbon financial performance evaluation index system based on extensive reading of previous literature, as shown in Table 1.

Table 1. Carbon financial performance assessment index system for the power generation industry

Objective Level	Criteria Level	Indicator Level	Indicator Meaning
Carbon Financial Performance (A)	Profitability (B_1)	Return on net assets(C_1)	Net profit/Average assets
		Net profit margin(C_2)	Net profit/Main operating income
		Return on total assets(C_3)	Net Profit/Average total assets
		Operating profit margin(C_4)	Operating income/Operating profit
		Cost margin(C_5)	Cost of main business/ Operating cost
	Operating Capacity (B_2)	Inventory turnover ratio(C_6)	Operating Cost/Average total inventory
		Fixed assets turnover(C_7)	Operating income/Average net fixed assets
		Total assets turnover(C_8)	Operating income/Average total assets

Solvency Capacity (B_3)	Current ratio(C_9)	Current assets/Current liabilities
	Gearing ratio(C_{10})	Total liabilities/Total assets
	Quick ratio(C_{11})	Quick assets/Current liabilities
Development capacity (B_4)	Operating income growth rate (C_{12})	Increase in operating income for the period/Operating income for the previous period
	Total assets growth rate(C_{13})	Increase in total assets for the period/Total assets at the beginning of the period
	Operating profit growth rate (C_{14})	Increase in operating profit for the period/Operating profit for the previous period
Low-Carbon Capability (B_5)	ESG environmental score(C_{15})	Bloomberg Database ESG environment score
	R&D expense ratio (C_{16})	R&D expenses/Operating revenue
Social Responsibility (B_6)	ESG social score(C_{17})	Bloomberg ESG social score
	Asset tax rate(C_{18})	Taxes paid / Total assets

Step 1: Confirmation of indicator weights using CRITIC assignment method

The calculation steps are:

(1) Let there be a total of m evaluation objects, n evaluation indicators are selected, and the original data matrix is obtained $A=(x_{ij})_{m\times n}$.

$$A=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{1}$$

(2) Data standardization

In order to eliminate the influence of different magnitudes on the evaluation results, the indicators need to be standardized. All the indicators selected in this paper are positive indicators, and the calculation formula is as follows.

Positive indicators.

$$r_{ij}^{+}=\frac{x_{ij}-x_{minj}}{x_{maxj}-x_{minj}} \tag{2}$$

Where: x_{ij} - the j th indicator of the i th company (0<i≤m, 0<j≤n).

(3) Calculate the contrast intensity S_j within each indicator.

The standard deviation is used to determine the contrast intensity of the indexes, and the larger the standard deviation, the greater the contrast intensity.

$$S_j=\sqrt{\frac{\sum_{i=1}^{m}(x_{ij}-\bar{x}_j)^2}{n-1}} \tag{3}$$

(4) The conflictiveness between indicators R_j is calculated.

The conflict of indicators is calculated based on the correlation between indicators, and the stronger the positive correlation between indicators, the smaller the conflict. The formula is as follows:

$$R_j=\sum_{i=1}^{m}(1-r_{ij}) \tag{4}$$

(5) Calculate the amount of information C_j for each indicator.

$$C_j = S_j \sum_{i=1}^{m}\left(1 - r_{ij}\right) = S_j \times R_j \tag{5}$$

(6) Calculate the weights w_j for each indicator.

$$w_j = \frac{C_j}{\sum_{j=1}^{n} C_j} \tag{6}$$

(7) Construction of standardized weighted evaluation decision matrix $V = (v_{ij})_{m \times n}$

$$V = \begin{bmatrix} x_{11} \cdot w_{11} & x_{12} \cdot w_{12} & \cdots & x_{1n} \cdot w_{1n} \\ x_{21} \cdot w_{21} & x_{22} \cdot w_{22} & \cdots & x_{2n} \cdot w_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} \cdot w_{m1} & x_{m2} \cdot w_{m2} & \cdots & x_{mn} \cdot w_{mn} \end{bmatrix} \tag{7}$$

(8) The calculated results are shown in Table 2

Table 2. Results of CRITIC weights for each indicator

C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
4.77%	3.91%	4.54%	3.89%	4.13%	5.87%	5.62%	7.34%	6.87%
C_{10}	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**	**C_{15}**	**C_{16}**	**C_{17}**	**C_{18}**
7.21%	6.60%	4.51%	5.19%	4.15%	7.12%	6.60%	7.82%	3.87%

Step 2: Analysis of sample data using TOPSIS comprehensive evaluation method

1. Calculate the positive and negative ideal solution values

Based on the standardized weighted evaluation decision matrix, the positive ideal solution value V^+ and the negative ideal solution value V^-, are calculated, i.e.

$$V^+ = (v_1^+, v_2^+, \dots, v_j^+, \dots v_n^+) \tag{8}$$

$$V^- = (v_1^-, v_2^-, \dots, v_j^-, \dots v_n^-) \tag{9}$$

$$v_j^+ = \{(\max_{1 \le i \le m} v_{ij} \mid j \in J^+), (\min_{1 \le i \le m} v_{ij} \mid j \in J^-)\} \tag{10}$$

$$v_j^- = \{(\min_{1 \le i \le m} v_{ij} \mid j \in J^+), (\max_{1 \le i \le m} v_{ij} \mid j \in J^-)\} \tag{11}$$

2. Calculate the Euclidean distances D_J^+, D_J^- for each solution to the positive ideal solution and negative ideal solution

Based on the weights obtained by objective assignment, the weighted Euclidean distance method is used to calculate the distances from each evaluation index to the positive ideal solution $V^+$and the negative ideal solution V^- and for different study subjects, denoted as d_i^+ and d_i^-.

The equation of the distance to the positive ideal solution:

$$d_i^+ = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^+\right)^2} \tag{12}$$

Equation for the distance to the negative ideal solution:

$$d_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2} \tag{13}$$

The larger value of d_i^+ indicates that the distance between the evaluated index and V^+ is farther, and the corresponding evaluated index has a lower score; the larger value of d_i^- indicates that the distance between the evaluated index and V^- is farther, and the corresponding evaluated index has a higher score.

3. Calculating carbon financial performance score for power generation companies

The comprehensive evaluation of the research object can be achieved by combining the scores of V^+ and V^- of each index. The carbon financial performance score T_i of power generation enterprises can be expressed as:

$$T_i = \frac{d_i^-}{d_i^- + d_i^+} \tag{14}$$

Scores are obtained in the range of 0-1, and the closer the score is to 1, the better the carbon nuclear financial performance of the power generation company. On the contrary, the closer the score is to 0, the worse is the carbon financial performance of power generation companies.

The calculated results are shown in Table 3.

Table 3. TOPSIS evaluation results of sample data

Company code	Positive ideal solution distance D^+	Negative ideal solution distance D^-	Relative proximity C	**Sorting result**
002039	13.026	3030.429	0.996	**1**
600452	1840.871	1189.622	0.393	**2**
600995	2987.623	42.930	0.014	**3**
600900	3010.212	23.246	0.008	**4**
600098	3027.531	16.110	0.005	**5**
600021	3018.877	15.322	0.005	**6**
601991	3025.277	14.813	0.005	**7**
600027	3023.899	14.293	0.005	**8**
600780	3016.866	14.148	0.005	**9**
000543	3018.587	12.009	0.004	**10**
000027	3026.710	11.692	0.004	**11**
600011	3026.147	10.845	0.004	**12**
600886	3025.554	10.146	0.003	**13**
600674	3029.390	9.570	0.003	**14**
600863	3021.849	8.952	0.003	**15**
000883	3023.294	8.386	0.003	**16**
600578	3026.440	8.370	0.003	**17**
000539	3027.336	7.567	0.002	**18**
600116	3023.825	7.457	0.002	**19**
600795	3024.379	7.229	0.002	**20**
600642	3025.593	7.172	0.002	**21**
600163	3026.116	6.891	0.002	**22**
600505	3026.021	6.621	0.002	**23**
002608	3024.546	6.561	0.002	**24**
600483	3026.438	6.458	0.002	**25**
000690	3027.326	6.358	0.002	**26**
600644	3024.872	6.262	0.002	**27**
000600	3025.295	5.886	0.002	**28**
000993	3030.450	5.404	0.002	**29**
600236	3025.165	5.364	0.002	**30**
000591	3025.869	5.128	0.002	**31**
600310	3028.193	4.439	0.001	**32**

5. Results and Discussion

The weighting coefficients of the 18 financial indicators of financial performance were calculated using the CRITIC assignment method, and the weighting coefficients of each indicator are shown in Table 2. The social score has the highest variability, which means that the ESG social score has more obvious differences and contains more information than other indicators.

By arranging the calculated weight coefficients from largest to smallest, the top five indicators in terms of weight are ESG social score, total asset turnover ratio, gearing ratio, ESG environmental score, and current ratio ESG, as one of the feasible criteria to assess the level of high-quality development of listed companies, is a matrix index system to comprehensively assess the environmental sustainability, social value and governance ability of enterprises. By embedding indicators such as human capital and employee health, ESG social score can effectively measure a company's green development capability, reflect the coordination and balance between the company and its stakeholders, and thus improve the valuation of the company. Information asymmetry, reflecting the potential and difficult to quantify risks of a company's sustainability, is an effective supplement to the traditional financial index system and provides more information. The large variability of ESG scores of listed companies in the power industry is due to the fact that, on the one hand, strong solvency, profitability and reasonable capital structure can help companies fulfill their responsibilities to the environment and society, but good operating capacity can make companies ignore the importance of sustainable development. On the other hand, ESG investment and CSR disclosure in China are still in the initial development stage, while the overall concentration of China's power industry has increased and is in the maturity stage, with more stable financial performance, and investors and corporate managers pay less attention and are less sensitive to the company's sustainability than in the West. Therefore, the ESG social score of power industry enterprises is influenced by both the business ability of enterprises and the financial market, and the value of indicators varies widely and the change of the score of the same enterprise in the past three years is small.

Total asset turnover ratio is the ratio of net sales revenue to average total assets for a certain period of time, which is an indicator of the ratio between asset investment scale and sales level. Factors affecting the total asset turnover ratio include total assets at the beginning of the period, total assets at the end of the period and net income from main business, which is an important indicator to examine the efficiency of an enterprise's asset operation. As a typical asset-heavy industry with large capital investment and long cycle, a high total asset turnover ratio reflects the high flow speed of all assets from input to output during the enterprise's operation and reflects the management quality and utilization efficiency of all assets. It integrates the accounts in the balance sheet and income statement, so the total asset turnover rate is closely related to the profitability of the enterprise, but higher profitability may come from less profit and operating income, so it does not necessarily mean higher asset turnover rate. In addition, the power industry, especially the power supply enterprises' ability to control sales revenue is influenced by multiple factors such as economic forms, government planning of operating regions, customer structure, etc. Therefore, the total asset turnover ratio varies greatly from enterprise to enterprise, and it is a comprehensive reflection of the enterprise's operating capacity and external environment, which is more informative. The development stage of the industry and the lack of pricing autonomy also explain the low weight of the indicators reflecting the profitability of the company.

According to the evaluation index system for the 32 electric power companies to rank the scores of the top three financial performance of the company number 002039, 600452, 600995. which, the number 002039 and 600452 enterprises scored significantly higher than the rest of the enterprises, the reasons for which are as follows.

For the company numbered 002039, firstly, it is mainly engaged in hydroelectric power generation, so its average inventory in each year is lower compared to the companies mainly engaged in thermal power generation, and its inventory turnover ratio is significantly higher. Secondly, the company has been in business for more than 20 years and has a well-developed power infrastructure within its business scope. With the support of policies such as "West-to-East" and "Qian-to-Guangdong", the company has developed projects in multiple basins, and has a large scale of assets and installed capacity and a mature operating model. It is noteworthy that the enterprise insists on the development concept of clean, environmental protection, high efficiency and harmony in the project construction. In the project design and construction, the Clean Development Mechanism (CDM) of the Kyoto Protocol, which came into effect on February 16, 2005, was introduced, bringing benefits to the power plant while maintaining environmental protection, fulfilling the social responsibility of state-controlled enterprises, and focusing on the construction of corporate culture, hence the high ESG score.

The company, No. 600452, is mainly engaged in distribution network energy-saving services, which is one of the main directions of carbon emission reduction of the State Grid and is expected to become the main investment body after the release of the "Carbon Peak, Carbon Neutral" action plan by the State Grid. At the same time, the company's energy saving projects have continued to improve in terms of project quality, operation level and cost control, and it has established high barriers to entry through active investment in fixed asset construction, which has to a certain extent reduced the possibility of a decline in distribution network yields due to increased competition, leading to steady growth in revenue and net profit in recent years and the ability to maintain a high return on net assets and inventory turnover.

Overall, the 32 companies selected for this study have poor ESG scores, and their overall operating and solvency capabilities need to be improved. In the context of "double carbon", how to realize the clean utilization of coal, promote green energy consumption, and achieve energy saving and emission reduction and efficiency is still an issue to be considered by enterprises and the government.

6. Conclusion

By constructing a carbon finance index evaluation system and assessing 32 listed electric power enterprises using the CRITIC-TOPSIS method, this paper incorporates low-carbon capability and social responsibility into the consideration system, comprehensively analyzes the real challenges and realization paths of carbon finance development at the micro level, enriches the theoretical research related to carbon finance, and provides theoretical support for the realization of the "double carbon This paper provides theoretical support and reference decisions for the realization of the "double carbon" strategic goal.

Although this paper presents an innovation for carbon finance theory, it still has shortcomings. First, because the disclosure of carbon accounting information in China is still at the stage of voluntary disclosure, the data collection is difficult, the sample is small and not concentrated, and it is difficult to construct the carbon finance index system, which cannot realize the realistic evaluation and future prediction of the whole power industry with extensive data; second, the carbon finance performance evaluation index system constructed in this paper lacks the support of empirical research, and is still at the stage of theoretical research, which cannot provide a high strategic deployment for enterprises Secondly, the carbon financial performance evaluation index system constructed in this paper lacks empirical research support and is still at the stage of theoretical research, which cannot provide high practical value for enterprise strategy deployment.

Since China lags in the development of carbon trading and carbon accounting and there is a gap with the international frontier level, in the future, we have a long way to go in carbon trading and carbon accounting. Based on this, the following are the prospects for future research: (1) to accelerate the construction of a perfect carbon finance and carbon accounting system to provide a theoretical basis for practical innovation; (2) to explore the external conditions and endogenous dynamics of corporate carbon information disclosure, strengthen the binding force of enterprises, and promote the healthy development of carbon trading market.

7. Recommendations

Under the requirement of "double carbon" target, electric power enterprises are facing a serious challenge. For the practical application of carbon financial performance evaluation index system in the power industry, the author proposes the following suggestions.

Firstly, under the low carbon economy, enterprises should optimize their long-term energy structure by building clean energy projects such as hydropower and wind power or actively laying out power saving projects, diversify their business and improve the efficiency of fixed assets, reduce carbon emissions and thus enhance their sustainable development ability, and integrate ESG concept into their development planning.

Secondly, in the context of international investors' increasing attention to corporate environmental protection capabilities, companies can actively improve their ESG performance to gain investors' attention and the state's encouragement, thus forming a positive cycle of "green investment-green financing-green investment" and accelerating corporate transformation.

In addition, government agencies should accelerate the establishment of carbon emission performance assessment standards for electric power enterprises, set up punitive measures to force enterprises to accelerate scientific research and project investment related to energy saving and emission reduction, and guide the capital market to inject funds into enterprises that effectively save energy and reduce emissions.

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