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Carbon Information Disclosure Quality and Corporate Financial Performance- Based on Empirical Data from the Electricity and Heat Production and Supply Industry

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Abstract: *Realizing high-quality growth necessitates achieving economic development with low carbon emissions. Enterprises, as the primary drivers of energy conservation and emission reduction in China, should proactively engage with China's carbon reduction initiatives and contribute to the realization of the "dual carbon" goal. This study empirically examines listed companies in the electricity and heat production and supply industry on the A-share market of the Shanghai and Shenzhen stock exchanges from 2019 to 2023, as classified by CSRC. The findings indicate that high-quality carbon information disclosure significantly enhances a company's financial performance, aiming to incentivize enterprises to improve their carbon information disclosure quality.*

Keywords: *carbon information disclosure quality; enterprise financial performance; green development*

1. Introduction

In order to effectively achieve the restrictive targets for energy conservation and carbon reduction outlined in the "14th Five-Year Plan," the State Council of China issued the "2024-2025 Action Plan Energy Conservation and Carbon Reduction" on May 29, 2024 (hereinafter referred to as the "Action Plan"). This plan sets forth specific requirements for carbon emissions and energy consumption indicators over the next two years. The "Action Plan" emphasizes controlling fossil energy strengthening carbon emission intensity management, and implementing targeted measures to promote energy efficiency and reduce carbon emissions across various sectors and industries. These initiatives will significantly impact people's lives and future enterprise development. As key contributors to efforts in energy conservation and emission reduction, enterprises are encouraged to actively engage in China's carbon reduction actions and contribute towards achieving the "dual-carbon" goals. The disclosure of corporate carbon information supports government oversight of carbon emissions, enhances external stakeholders' understanding of companies' efforts in reducing their carbon footprint, reduces information asymmetry, and fosters trust among investors and consumers. Various Chinese government departments are continuously advancing efforts to enhance the quality of corporate carbon information disclosure. On May 27, 2024, the Ministry of Finance of China released the "Corporate Sustainable Disclosure Guidelines - Basic Guidelines (Draft for Comments)," marking a pivotal shift from policy guidance towards actual implementation of sustainable information disclosure practices in China while gradually standardizing disclosure requirements. Analyzing the relationship between the quality of carbon information disclosure and corporate financial performance holds significant practical value as it enables enterprises to better comprehend how such disclosures impact their interests while motivating them toward greater transparency.

The electricity and heat production and supply industry refers to the industry that uses coal, oil, natural gas, nuclear energy, etc. as energy raw materials, converts them into electricity, heat energy and other products by means of heat, water power, wind power, etc., and then provides them to all fields of society. Enterprises in this industry have historically been major contributors to China's overall carbon emissions, which not only supports the development of China’s economy, but also undertakes the responsibility of green low-carbon transformation of the economy, and is also the focus of various reduction tasks in China. Based on the empirical data of listed companies in the electricity and heat production and supply industry, this paper studies the relationship between the quality of carbon information disclosure and corporate financial performance.

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2. Theoretical analysis and research hypothesis

The relationship between the quality of carbon information disclosure and corporate financial performance has always been the focus of scholars' research. Li and Shi (2016) selected the constituent enterprises of SSE Social Responsibility Index from 2011 to 2014 as samples, analyzed the relationship between the quality of carbon information disclosure and the financial performance of enterprises by using the two-stage least square method, and found that the quality of carbon information disclosure and the financial performance of enterprises were significantly positively correlated. Moreover, the positive effect of carbon information disclosure quality of non-state-owned listed companies will be more obvious.[1] Zhang (2018) selected China's top 500 enterprises listed on Shanghai Stock Exchange and Shenzhen Stock Exchange from 2013 to 2015 as samples to analyze the impact of carbon information disclosure quality on corporate profitability, solvency, operating ability and growth ability, and concluded that the improvement of the quality of carbon information disclosure will have a positive impact on the profitability and operation capacity of enterprises. [2] Xu, Cheng and Du (2022) selected listed companies in heavily polluting industries from 2016 to 2020 for sample analysis and found that the improvement of carbon information disclosure quality would reduce the financing cost of enterprises and thus improve their financial performance.[3] Shi, Zhang and Cao (2023) analyzed the relationship between the quality of carbon information disclosure and enterprises' R&D investment and financial performance by taking advanced manufacturing listed companies from 2019 to 2022 as samples, and found that the quality of carbon information disclosure would promote the improvement of enterprises' financial performance, in which R&D investment played an intermediary effect. [4] Liu and Chen (2024)selected listed companies in high-carbon emission industries from 2015 to 2020 as samples, evaluated the carbon information disclosure level of enterprises through text analysis technology, and studied the relationship between the quality of carbon information disclosure and enterprise value, and concluded that the improvement of carbon information disclosure quality would inhibit the growth of enterprises' short-term value (return on total assets). However, it will promote the long-term value (stock market value) of enterprises, and carbon information disclosure cannot affect the short-term value of enterprises by easing financing constraints.[5] These literatures analyzed the relationship between carbon information disclosure and firm performance from different perspectives, providing inspiration for the selection of explanatory variables and explained variables in this paper. However, it can also be found that the current research on the impact of carbon information disclosure on corporate financial performance has not reached a unified conclusion, and some research conclusions are even contradictory, which requires more scholars to adopt different methods to conduct research and verification.

According to the stakeholder theory, the survival and development of enterprises depend on the response and satisfaction of the requirements of various stakeholders. In the era where green development has become a consensus, businesses are required to meet demands for social sustainability through environmental protection measures such as energy conservation and emissions reduction. Carbon information disclosure serves as an initial step in fostering environmentally responsible business practices. Comprehensive transparency regarding carbon data not only facilitates stakeholder comprehension but also bolsters investor confidence while garnering increased support from resources. Furthermore,according to the signal transmission theory, the strong carbon information disclosure of enterprises also shows the environmental awareness and social responsibility of enterprises, which is conducive to the formation of a good reputation, attracting more investors and consumers, thereby increasing market share. In addition, in the process of carbon information disclosure, enterprises will pay more attention to their own energy consumption and resource waste, improve process technology, improve resource utilization efficiency, reduce costs, and thus improve performance. Therefore, this paper makes the following hypothesis: the quality of carbon information disclosure has a positive impact on corporate financial performance.

3. Study design

3.1 Sample selection and data source

This paper selects listed companies in the electricity and heat production and supply industry on the A-share market of the Shanghai and Shenzhen stock exchanges from 2019 to 2023 in the industry classification of CSRC as samples, and after excluding ST, *ST and enterprises with missing key data, a total of 347 effective observations are collected from 79 enterprises (only post-listing data are available for newly listed enterprises within five years).The data come from iFinD, Choice and Wind

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databases. The data processing tool is SPSS 25.0.

3.2 Variable description

3.2.1 Explained variable

Corporate financial performance: Rate of return on total assets (ROA) is the ratio between the net profit of an enterprise and the average total assets, which reflects the income created by each yuan invested in assets of an enterprise and can reflect the overall profitability of the enterprise's assets. Therefore, the return on total assets is selected in this paper to measure the financial performance of an enterprise.

3.2.2 Explanatory variable

Carbon information disclosure quality. Currently, the majority of studies assess the quality of carbon information disclosure using a rating table, with experts scoring annual reports and social responsibility reports from companies. This approach is somewhat subjective. Shanghai Huazheng Index Information Service Co., Ltd, a company specializing in comprehensive index and index investment services, provides a more scientific and objective third-party assessment. This paper selects the comprehensive score from Huazheng ESG as an indicator of the quality of carbon information disclosure.

3.2.3 Control variables

With reference to existing research results, this paper selects asset-liability ratio, total asset turnover ratio, growth rate of operating income, scale and nature of property right as control variables, and controls the region and year. Among them, the asset-liability ratio is the ratio of total liabilities to total assets, reflecting the financial leverage level and long-term solvency of the enterprise. The higher the asset-liability ratio, the weaker the long-term solvency of the enterprise and the higher the financial risk. Total assets turnover ratio is the ratio of operating income to average total assets, reflecting the operating income generated by each yuan invested in assets, and also reflecting the utilization efficiency of assets of an enterprise. The higher the total assets turnover ratio, the better the operation capacity of an enterprise. The growth rate of operating income is an important indicator reflecting the growth ability of enterprises. The higher the growth rate of operating income, the better the development of enterprises and the stronger the market share. Scale reflects the size of enterprise assets. In order to reduce the gap between the values of various indicators, this paper uses the natural logarithm of the total assets at the end of the period as a measure of scale. Compared with non-state-owned enterprises, state-owned enterprises need to undertake more obligations and be subject to more supervision. In this paper, the nature of property right is set as a dummy variable, 1 for state-owned enterprises and 0 for non-state-owned enterprises, so as to control the influence of property right nature on the financial performance of enterprises. Due to the different environmental policies in different regions of China and the different economic situations in different years, this paper sets dummy variables for each region (eastern, western and central regions) and year (2019-2023) for control. The specific variable definitions are shown in Table 1.

Table 1: Variable Definitions

Type of Variables	Name of Variables	Symbol of Variables	Definition of Variables
Explained variable	Return on total assets	ROA	Net profit/average total assets
Explanatory variable	Carbon information disclosure quality	CDI	Comprehensive score from Huazheng ESG
Control variables	Asset-liability ratio	LEV	Total liabilities/total assets
	Total asset turnover ratio	TURNOVER	Operating income/average total assets
	Growth rate of operating income	GROWTH	(Current Year's operating income - last year's operating income)/last year's operating income
	Scale	SIZE	Natural logarithm of the total assets at the end of the period
	Nature of property right	STATE	1 for state-owned enterprises, 0 for non-state-owned enterprises
	Region	REGION	eastern, western and central regions
	Year	YEAR	2019-2023

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3.3 Model construction

This paper uses a multiple linear regression model to test the impact of carbon information disclosure quality on corporate financial performance. The model is constructed as follows:

$$ROA_{i,t} = \beta + +\beta_1 CDI_{i,t} + \beta_2 LEV_{i,t} + \beta_3 TURNOVER_{i,t} + \beta_4 GROWTH_{i,t} + \beta_5 SIZE_{i,t} + \beta_6 STATE_{i,t} + \sum REGION + \sum YEAR + \varepsilon_{i,t}$$

i indicates enterprise; t stands for time; ROA stands for return on total assets; CDI represents the quality of carbon information disclosure; LEV, TURNOVER, GROWTH, SIZE, STATE, REGION and YEAR are control variables, representing asset-liability ratio, total asset turnover, growth rate of operating income, scale, nature of property right, region and year respectively. ε represents random error; β represents the constant term; β1 to β6 represent the coefficients of each variable.

4. Empirical analysis

4.1 Descriptive statistics

Table 2 shows the characteristics of sample variables. The minimum value of return on total assets (ROA) of the explained variable is -0.346, the maximum is 0.208, the average value of the industry is 0.023, and the standard deviation is 0.048, indicating that the financial performance of enterprises in the electricity and heat production and supply industry is relatively different, and the overall is low. The minimum value of the explanatory variable, carbon information disclosure quality (CDI), is 61.020, the maximum value is 87.670, and the average value is 73.337, indicating that the carbon information disclosure quality of enterprises in this industry is generally good. The asset-liability ratio (LEV) ranges from 0.042 to 1.334, with an average value of 0.573 and a standard deviation of 0.178, indicating a large difference in the debt level of enterprises in this industry. The total asset turnover (TURNOVER) ranges from 0.024 to 1.195, with an average of 0.336, indicating that the operating level of different enterprises varies greatly, and the overall asset operating capacity of the industry is low.The mean value of the growth rate of operating income (GROWTH) is 0.185, and the standard deviation is 1.219, indicating that there is a wide gap in the growth capacity among enterprises. The data of nature of property right (STATE) show that state-owned enterprises in this industry account for a large proportion, and state-owned enterprises will be more responsive to national policies and more actively fulfill their obligations of carbon information disclosure.

Table 2: Variable Descriptive Statistical Analysis

	N	Min	Max	Mean	Standard Deviation
ROA	347	-0.346	0.208	0.023	0.048
CDI	347	61.020	87.670	73.337	4.447
LEV	347	0.042	1.334	0.573	0.178
TURNOVER	347	0.024	1.195	0.336	0.199
GROWTH	347	-0.490	22.099	0.185	1.219
SIZE	347	20.211	27.072	23.979	1.538
STATE	347	0	1	0.84	0.363

4.2 Correlation Analysis

In this paper, Pearson correlation analysis is used to preliminarily verify the relationship between the variables. According to Table 3, the correlation coefficient between carbon information disclosure quality (CDI) and return on total assets (ROA) is 0.299, and is significant at the level of 0.01 (double tail), which verifies the hypothesis in this paper that the improvement of carbon disclosure quality can promote the improvement of corporate financial performance. The correlation coefficient between asset-liability ratio (LEV) and return on total assets (ROA) is -0.568, and is significant at 0.01 level (double tail), indicating that excessive financial leverage will increase the financial risk of enterprises and reduce the financial performance of enterprises. The correlation coefficient between property rights (STATE) and return on total assets (ROA) is -0.107, which is significant at the 0.05 level (double tail), indicating that the financial performance of state-owned enterprises in this industry is weaker than that of non-state-owned enterprises. In addition, the absolute values of the correlation coefficients of the

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following variables are all less than 0.6, indicating that serious collinearity problems will not occur in subsequent regression analysis.

Table3: Pearson Correlation Analysis

	ROA	CDI	LEV	TURNOVER	GROWTH	SIZE	STATE
ROA	1						
CDI	0.299**	1					
LEV	-0.568**	-0.113*	1				
TURNOVER	0.074	-0.109*	-0.164**	1			
GROWTH	0.088	-0.035	0.024	0.170**	1		
SIZE	-0.023	0.365**	0.386**	-0.207**	0.017	1	
STATE	-0.107*	0.159**	0.323**	-0.004	-0.09	0.313**	1

Note: **. indicates statistical significance at level 0.01 (two-tailed). *. indicates statistical significance at level 0.05 (two-tailed).

4.3 Regression analysis

It can be seen from Table 4 that the R2 of the regression model is 0.433, and the adjusted R2 is 0.412, indicating that the model has a good degree of fitting, and the Durbin-Watson value is between 0 and 4, which is 1.275, indicating that the data independence is consistent. As can be seen from Table 5, the F statistic of the regression model is 21.234, and the p value is less than 0.001, which means that the model is significant and the multiple linear regression equation fitted is statistically significant. According to Table 6, corporate carbon information disclosure quality (CDI) is positively correlated with corporate financial performance (ROA), and the coefficient is 0.001, which is significant at the level of 0.01, further verifying the hypothesis of this paper that the improvement of carbon disclosure quality will promote the growth of corporate financial performance. At the same time, the variance inflation factors (VIF) of this model range from 1.075 to 1.648, all of which are significantly less than 10, which once again proves that this model has no multicollinearity problem.

Table 4: Model Summaryb

R	R2	Adjusted R2	Standard Error of the Estimate	Durbin-Watson
.658a	0.433	0.412	0.037	1.275

a.Explanatory variabl(Constant),CDI,LEV,TURNOVER,GROWTH,SIZE,STATE,REGION,YEAR
b.Explained variable:ROA

Table 5: ANOVAa

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.340	12	0.028	21.234	.000b
Residual	0.446	334	0.001		
Total	0.786	346			

a.Explained variable:ROA
b.Explanatory variable:(Constant),CDI,LEV,TURNOVER,GROWTH,SIZE,STATE,REGION,YEAR

Table 6: Regression Results of Carbon Information Disclosure Quality and Corporate Financial Performance

Model	Unstandardized Coefficient		Standardized Coefficient	t	Sig.	Collinearity Statistics	
	B	Std.Error	Beta			Tolerance	VIF
(Constant)	-0.135	0.044		-3.095	0.002		
CDI	0.001	0.001	0.136	2.612	0.009	0.626	1.596
LEV	-0.161	0.013	-0.602	-12.195	0.000	0.698	1.433
TURNOVER	0.008	0.011	0.034	0.762	0.447	0.853	1.172
GROWTH	0.004	0.002	0.101	2.374	0.018	0.930	1.075
SIZE	0.006	0.002	0.184	3.487	0.001	0.607	1.648
STATE	-0.001	0.006	-0.005	-0.107	0.915	0.750	1.333

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5. Robustness test

In order to test the reliability of the empirical results in this paper, the robustness test is carried out by two methods: lagging the explained variable by one period and shortening the time horizon.

5.1 Lagging the explained variable by one period

The effect of improving the quality of carbon information disclosure on enterprises may have a lag and will not be immediately reflected in the current year. Therefore, in the robustness test, this paper replaces the explanatory variable ROA with the ROA of the next period to conduct regression again. The results are shown in Table 7. The carbon information disclosure quality is still positively correlated with the ROA of the next period, and is significant at the level of 0.01, which proves the robustness of the research conclusion of this paper and avoids the possible reverse causality.

Table 7: Robustness test results of lagging the explained variable by one period

	Unstandardized Coefficient		Standardized Coefficient	t	Sig.	Collinearity Statistics	
	B	Std.Error	Beta			Tolerance	VIF
(Constant)	-0.221	0.054		-4.065	0.000		
CDI	0.004	0.001	0.326	5.133	0.000	0.609	1.641
LEV	-0.103	0.017	-0.368	-6.204	0.000	0.701	1.426
TURNOVER	0.001	0.013	0.003	0.054	0.957	0.832	1.203
GROWTH	0.002	0.002	0.064	1.227	0.221	0.917	1.090
SIZE	0.002	0.002	0.077	1.215	0.226	0.611	1.637
STATE	-0.008	0.008	-0.061	-1.075	0.283	0.756	1.322

Note: Explained variable: ROA of the next period

5.2 Shortening the time horizon

The carbon peaking and carbon neutrality goals were clearly proposed on September 22, 2020. Shortening the time horizon and placing the time range of observation data after the "dual carbon" goals were proposed helps to exclude the influence of other policies and better understand the impact of the quality of corporate carbon information disclosure on financial performance under the background of "dual carbon policy". In the robustness test, this paper controls the sample time range from 2021 to 2023, eliminates the two control variables of REGION and YEAR, and conducts multiple linear regression again. The regression results are shown in Table 8. The coefficient of carbon information disclosure quality (CDI) and return on total assets (ROA) is 0.002. It is significant at the level of 0.05, which further proves that improving the level of carbon information disclosure will promote corporate financial performance, and this effect is more obvious after the introduction of the "two-carbon" policy.

Table 8: Robustness test results of shortening the time horizon

	Unstandardized Coefficient		Standardized Coefficient	t	Sig.	Collinearity Statistics	
	B	Std.Error	Beta			Tolerance	VIF
(Constant)	-0.140	0.060		-2.339	0.020		
CDI	0.002	0.001	0.147	2.509	0.013	0.737	1.358
LEV	-0.187	0.018	-0.659	-10.443	0.000	0.638	1.567
TURNOVER	-0.001	0.013	-0.004	-0.072	0.943	0.901	1.110
GROWTH	0.026	0.009	0.141	2.692	0.008	0.932	1.073
SIZE	0.005	0.002	0.135	2.082	0.039	0.603	1.658
STATE	0.008	0.008	0.059	1.015	0.311	0.759	1.317

Note: Explained variable: ROA

6. Conclusions and Implications

Taking the listed companies in the electricity and heat production and supply industry on the A-share market of the Shanghai and Shenzhen stock exchanges from 2019 to 2023 in the industry classification of CSRC as a case study，this paper examines the correlation between carbon information disclosure quality and corporate financial performance. It concludes that high-quality carbon

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information disclosure positively influences corporate financial performance, and enhancing the quality of such disclosure will foster growth in financial performance.

Based on the aforementioned research findings, this paper proposes the following recommendations: Firstly, enterprises should bolster their commitment to carbon information disclosure, fully acknowledge its positive impact on financial performance, integrate it into strategic planning and daily operations, and further enhance its quality.[6] Secondly, governments should continue to establish and refine carbon information disclosure systems and regulations, standardize requirements for carbon information disclosures, offer guidance to companies on disclosing carbon information, as well as improve transparency and comparability. Thirdly, strengthen the external supervision and incentive of carbon information disclosure, encourage enterprises to introduce third-party audit institutions to verify the content of carbon information disclosure, strengthen the attention and supervision of social media and the public to corporate carbon information disclosure, and promote enterprises to fulfill their social responsibilities and carry out strong carbon information disclosure.

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