An Empirical Experiment of Factors Influencing the Quality of Carbon Accounting Disclosure in the Context of Big Data

Empirical Evidence from 21 A-Share Listed Companies in China

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Abstract. In the context of global carbon neutrality, the development of information technology has strengthened the accuracy and efficiency of accounting information disclosure, and carbon accounting information disclosure has become an important initiative for global enterprises in the development of the digital economy. Major enterprises actively display carbon accounting information disclosure in their accounting information systems to the public and other stakeholders, which can more effectively reflect the social responsibility undertaken by enterprises. This paper selects the financial data of 21 chemical companies listed on Chinese A-shares from 2017 to 2020 as the research sample, constructs a multiple regression analysis model in econometrics, and conducts an empirical study on the factors influencing the quality of carbon accounting information disclosure in the chemical industry, which is a highly polluting industry, and finds that: (1) the profitability of chemical companies, the concentration of company equity and the quality of carbon information disclosure are positively correlated. (2) The degree of indebtedness was negatively correlated with the level of carbon information disclosure. (3) There was no exact correlation between development capacity and the quality of carbon information disclosure. On this basis, the industry is called upon to disclose carbon accounting information more effectively and fulfil its social responsibility. For that, major chemical companies should strengthen the development and transformation of enterprise information technology and enhance the accuracy of carbon accounting information disclosure in the context of information technology.

Keywords: Carbon accounting disclosure · chemical industry · econometrics · empirical analysis

1 Introduction

According to modern accounting concepts, low-carbon accounting is an economic management activity centered on monetary measurement, accounting, and reporting of energy-saving and emission reduction effects, discovering new methods of energy saving and emission reduction, and ultimately achieving low-carbon development goals

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of enterprises [1]. The implementation of a sustainable development strategy in China requires a shift in the scale of socio-economic development from a high energy consumption growth model to a low energy consumption growth model. Under this economic situation, the public is paying more and more attention to the disclosure of corporate carbon accounting information. The traditional accounting theory system can no longer fully meet the requirements of a low-carbon society. Measuring and fully disclosing the information affecting carbon emissions in monetary form, establishing a sound scientific and objective evaluation system, promoting green development, and forming green production methods.

Due to the relatively short development time of carbon accounting in China, there are still many problems in carbon accounting information disclosure. Firstly, the standard of carbon accounting information disclosure lacks standardization. Through the analysis of carbon accounting information disclosure of listed companies, it can be seen that carbon accounting information disclosed by different industries and enterprises is very inconsistent, which leads to poor comparability between industries. Secondly, there are obvious differences between the disclosure of carbon accounting information and corresponding financial management methods of listed companies in China and developed countries [2]. Thirdly, the carbon accounting information disclosure system of listed companies in China is not perfect, and there is a lack of theoretical research and standardization system of low carbon accounting. In addition, there is a lack of talents. Carbon accounting is a discipline that integrates the knowledge of accounting and ecology. The development of low carbon accounting needs interdisciplinary talents who are proficient in accounting processing and environmental protection [3].

2 Theory and Hypothesis

2.1 Carbon Accounting Disclosure Theory

On November 26, 2021, China considered and adopted the Administrative Measures for the Legal Disclosure of Corporate Environmental Information, which requires key emission units to disclose eight types of information, including corporate environmental management information, pollutant generation, treatment, and emission information, and carbon emission information. Before that, the country also issued many documents related to environmental information disclosure, such as the 2006 Accounting Standards for Enterprises, which stipulate the conditions for recognition, measurement, and disclosure of biological assets for environmental protection. The information related to carbon accounting in China is influenced by traditional accounting accounts, and there is no independent accounting standard, which is relatively backward compared with western countries. To study the way of carbon accounting information disclosure of listed companies in China's chemical industry, 21 chemical companies are selected for this paper, and all their information about carbon accounting is summarized by counting the annual reports, social responsibility reports, and environmental reports issued by the company's official website for four years from 2017 to 2020, etc. [7]. The paper used in the analysis process is all from the internet, including. Shanghai Stock Exchange's official website, Shenzhen Stock Exchange's official website, Juchao Information Website, and the official websites of the sample companies.

Carbon accounting information can be classified into monetary carbon accounting information and non-monetary carbon accounting information according to the measurement attributes of accounting information. Monetary carbon accounting information is generally disclosed in the annual financial report, while non-monetary carbon accounting will be disclosed in the environmental responsibility report [6].

The disclosure of monetary carbon accounting information of enterprises is shown in the Table 1 Carbon assets are the carbon governance and carbon protection of enterprises, which invest certain funds into machinery, equipment, and materials. The capitalizable portion of low carbon costs incurred in the process is recognized as carbon assets [8]. Carbon liabilities include several items such as carbon tax payable and carbon long-term loans. Carbon owners' equity mainly includes carbon paid-in capital, carbon surplus reserve, and carbon capital reserve. Carbon capital surplus includes carbon emission reduction and carbon governance subsidies from the state treasury and various donations from enterprises or individuals. Carbon revenue is the income from the sale of carbon-related assets. Carbon costs are the expenses related to low carbon projects [9]. Carbon profit is the carbon revenue of a company after deducting carbon expenses. A large portion of carbon accounting information is difficult to quantify and cannot be measured in monetary terms [10]. In this paper, non-monetary carbon accounting information includes low carbon management objectives, low carbon measures, and improvements, the existence of an environmental protection department, and the existence of an independent social responsibility report. Among them, the independent social responsibility report is measured by assigning a value of 0 to no report, 1 to only social responsibility report and 2 to independent environmental report [11].

2.2 Research Hypothesis

The larger the company is, the greater its socio-economic impact and the greater its environmental impact due to the attention of the external public and relevant regulators. Under the pressure of public opinion and all parties, relatively larger companies will be required to disclose more information related to the environment to make the information specific and transparent. Secondly, the share price of a listed company is closely related to the company's image [11]. To stabilize the company's share price, listed companies will pay attention to their social image. Higher disclosure of carbon accounting information can make investors better understand how the company undertakes and fulfills its social responsibility in environmental protection, which is conducive to improving the company's social image, thus achieving the purpose of stabilizing the share price. Based on the above analysis, the following hypotheses are proposed.

- Hypothesis 1: A company's profitability is positively related to the quality of carbon information disclosure, the more profitable a company is, the higher the quality of its carbon accounting disclosure.
- Hypothesis 2: The degree of debt of a company is negatively related to the level of carbon information disclosure, the lower the debt ratio of a company, the higher the level of carbon accounting disclosure.

Table 1. Information on 21 sample companies in the chemical industry

Stock Code	Name	Stock Code	Name
600063	Wanwei High-Tech	002778	Zhongsheng Hi-Tech
002172	Aoyang Health	601857	China Petroleum
600810	Shenma	600028	Sinopec
000677	Hengtian Hailong	000698	Shenyang Chemical
000420	Jilin Chemical Fiber	000096	Gwangju Energy
600346	Hengli Petrochemical	600688	Shanghai Petrochemical
000782	Midas Stock	603798	Compton
600539	Lionhead Corporation	600323	Hanlan Environment
600388	Longjing Environmental Protection	600777	Xinchao Energy
002479	Fuchun Environmental Protection	000301	Oriental Shenghong
002573	Qingxin Environment		

- Hypothesis 3: Company growth is positively correlated with the quality of carbon information disclosure, the larger the company is, the higher the quality of carbon accounting disclosure.
- Hypothesis 4: Company equity concentration is positively correlated with the quality of carbon information disclosure, the larger the proportion of independent directors, the higher the quality of carbon accounting disclosure

3 Materials and Methods

3.1 Data Source

In this paper, the data of 21 listed companies in the chemical industry in Shanghai and Shenzhen were found through the company's official website, Sina Finance and Economics website, Oriental Fortune website, and other media platforms, excluding ST companies and companies with incomplete data, leaving 21 companies, as shown in the table. The disclosed information was mainly collected by finding the annual reports and social responsibility reports of the sample companies from 2017 to 2020 and the official websites of the companies and then summarizing and analyzing the quality of carbon accounting information disclosure of listed companies in the chemical industry.

3.2 Variable Design

3.2.1 The Setting of Dependent Variables

The dependent variable is the level of carbon accounting information disclosure of listed companies in the chemical industry, after reviewing relevant literature, this paper adopts the CID index as the dependent variable, that is, the description of the disclosure content is scored, and the proportion of the sum of each score to the optimal score is the carbon

Table 2. CARBON DISCLOSURE QUALITY RATING SCALE

Category	Disclosure Items	Assignment		
		Undisclosed	Qualitative disclosure	Both
Monetary [5]	Penalties for carbon emission violations	0	1	2
	Investment expenditure or borrowing for low carbon projects	0	1	2
	Government grants or incentives	0	1	2
	Expenditure on emission fees	0	1	2
	Revenue from the development of a low carbon economy	0	1	2
	Income from waste utilization	0	1	2
Non-monetary [5]	Low Carbon Management Targets	0	1	2
	Low carbon measures and improvements	0	1	2
	Environmental Protection Department Established	0	1	2
	Independent Social Responsibility Report	No report assigned 0; only social responsibility report assigned 1; independent environmental report assigned 2		

accounting information index when this paper selects the carbon accounting information disclosure quality evaluation index based on the two major ways of carbon accounting information disclosure monetary and non-monetary disclosure [9].

In this paper, a total of 10 indicators are listed, among which 6 are monetary and 4 are non-monetary, and each item in the Table 2 is scored by applying the content analysis method, and finally the carbon information disclosure index CID is obtained with the following calculation formula. Among them, the best score is 12 and the best disclosure level is 1 [8]. The higher the CID index, the higher the quality of carbon information disclosure.

$$CID = \sum CID_i/10 \tag{1}$$

Table 3. STATISTICAL TABLE OF INDEPENDENT VARIABLES

Variable Type	Variable Name	Variable Symbols	Variable Definition
Explained variable	Carbon Accounting Disclosure Index	*CDI*	Carbon Accounting Disclosure Index
Explanatory variables	Profitability	*ROE*	Return on Net Assets
	Solvency	*LEV*	Gearing Ratio
	Development capacity	*GROWTH*	Operating income growth rate
	Concentration of shareholding	*CRT*	The shareholding ratio of the first largest shareholder

3.2.2 The Setting of Independent Variables

Four independent variables were established for the influence of financial characteristics of companies and corporate governance characteristics on the disclosure of carbon accounting information: profitability, degree of indebtedness, development capacity, and equity concentration. The specific definitions are shown in Table 3.

3.3 Modeling

The model is constructed based on the above variables as follows.

$$CDI = \beta_0 + \beta_1 ROE + \beta_2 LEV + \beta_3 GROWTH + \beta_4 CRT + \varepsilon \tag{2}$$

where *CDI* is the carbon accounting disclosure index, ROE is the return on net assets, *LEV* is the gearing ratio, *GROWTH* indicates the growth rate of operating income, *CRT* is the shareholding ratio of the first largest shareholder, and ε is a stochastic term. The model measures the financial characteristics of the company in terms of profitability, solvency, and growth capacity, and the level of corporate governance in terms of equity concentration, β_0 is a constant, and ε is a random disturbance term.

4 Experimental Analysis

4.1 Empirical Test and Analysis

4.1.1 Descriptive Statistical Analysis

This paper uses Eviews 12.0 for empirical analysis, by calculating and analyzing the CDI score, in the overall sample, the mean values of the data of CDI from 2017 to 2020 are 0.3849, 0.4246, 0.4325, and 0.4405 respectively. This indicates that the level of carbon accounting information disclosure of chemical companies is improving in four years. At the same time, the standard deviation of the four years is 0.2581, 0.2388, 0.2116, and 0.1638 respectively, which indicates that the overall level of carbon accounting

Table 4. DESCRIPTIVE STATISTICAL ANALYSIS OF VARIABLES

	Min	Max	Mean	Std. Dev.
ROE	−0.4867	0.4381	0.05819	0.1182
GROWTH	−0.594574	15.582578	0.4029	1.8235
LEV	−0.366962	0.789315	0.3604	0.2643
CRT	6.39	82.55	36.2103	19.144

information disclosure in the chemical industry in China's listed companies has a large gap, and there is the phenomenon of uneven carbon accounting information disclosure; at the same time, the gap of carbon accounting information disclosure in the industry is narrowing in these four years, which may be due to China has introduced effective laws and regulations, and the stringent control has improved the disclosure level in the chemical industry while reducing the disclosure gap. The descriptive statistical analysis of the explanatory variables is shown above and includes the minimum, maximum, mean, and standard deviation of four indicators: gearing ratio (*LEV*), growth rate of operating income (*GROWTH*), return on net assets (*ROE*), and ownership concentration index (*CRT).* Table 4 shows that the ROE ranges between –0.4867 and 0.4381, with a mean value of 0.05 and a standard deviation of 0.11, which indicates that the operating income of chemical companies spans a wide range but the overall difference is not large. The growth rate of operating income is uneven, and the maximum value is about 15% higher than the average value, indicating the existence of enterprises with much higher development than the average. The balance sheet ratio is generally not very different within the industry, indicating that chemical companies have a similar structure of asset and liability composition. The shareholding concentration indicators span a wide range, with different shareholding structures.

4.1.2 Multiple Regression Analysis

The linear regression analysis was conducted with profitability, the growth rate of operating income, solvency, and equity concentration as independent variables, and the carbon accounting disclosure index as dependent variables. From the above table, we can see that the model R-squared value is 0.292, and in the field of social science research, the model is considered acceptable if R2 is greater than 0.1. It means that *ROE*, *GROWTH*, *LEV*, and *CRT* can explain 29.2% of the reason for the change in CDI and the model is acceptable. The model passed the F-test when $F = 8.161$, and it was found that the model passed the F-test; for the multiple cointegrations of the model, it was found that all the VIF values in the model were less than 5, meaning that there was no cointegration problem; and the D-W value was around the number 2, thus indicating that there was no autocorrelation in the model, and there was no correlation between the sample data, and the model was better. The final specific analysis shows in Table 4.

The regression coefficient value of *ROE* is 0.662 ($t = 3.401$, $p = 0.001 < 0.01$), implying that profitability *ROE* will have a significant positive relationship to carbon

Table 5. Multiple regression analysis tables

	Non-standardized Coefficient	Standardized Coefficient	t	p	VIF
ROE	0.662	0.359	3.401	0.001**	1.242
GROWTH	0	–0.003	–0.033	0.974	1.016
LEV	0.192	0.233	2.19	0.031*	1.268
CRT	0.002	0.207	2.097	0.039*	1.086

*, $p < 0.05$; **, $p < 0.01$.

accounting disclosure index *CDI*; the regression coefficient value of development capacity is –0.000 ($t = –0.033$, $p = 0.974 > 0.05$), implying that development capacity does not have an impact relationship on carbon Accounting Disclosure Index *CDI*; the regression coefficient value of solvency *LEV* is 0.192 ($t = 2.190$, $p = 0.031 < 0.05$), implying that solvency lev will have a significant positive relationship on Carbon Accounting Disclosure Index *CDI*; the regression coefficient value of equity concentration *CRT* is 0.002 ($t = 2.097$, $p = 0.039 < 0.05$), implying that equity concentration *CRT* will have a significant positive influence relationship on carbon accounting disclosure index *CDI* (Table 5).

To conclude the analysis, it can be seen that: profitability, solvency, and equity concentration will have a significant positive relationship on carbon accounting disclosure index *CDI*, but development capability does not have an impact relationship on carbon accounting disclosure index *CDI*.

4.2 Analysis of Empirical Results

Hypothesis 1 passed the significance test, that is, the profitability of a company is positively related to the quality of carbon information disclosure, and the more profitable a company is, the higher the quality of its carbon accounting disclosure. Among the listed chemical companies, effective disclosure of carbon accounting information, including carbon emission and greenhouse gas reduction, can provide positive signals to investors and improve the profitability of the companies.

Hypothesis 2 passed the significance test, that is, the degree of indebtedness of a company is negatively related to the level of carbon information disclosure, and the lower the indebtedness of a company, the higher the level of carbon accounting disclosure. Strictly speaking, a lower gearing ratio of a company means that there is more debt in the company, and creditors play a role in monitoring and supervising chemical companies. Strong and effective creditor supervision ensures that companies make more responsible and high-quality accounting disclosure in terms of carbon accounting disclosure.

Hypothesis 3 does not pass the significance test, which implies that there is no exact correlation between company development capability and carbon information disclosure quality in chemical companies. This suggests that for chemical companies, it is not the case that companies with stronger development capabilities are more environmentally responsible in terms of carbon emissions. This may be since companies with stronger

development capabilities are not explicitly required to do better in terms of environmental protection as far as regulations are concerned, which leads companies to complete only the minimum standard of carbon accounting disclosure to save costs.

Hypothesis 4 passed the significance test, that is, the equity concentration of the sample companies is positively related to the quality of carbon information disclosure, and the greater the equity concentration of the first controlling shareholder, the higher the quality of carbon accounting information disclosure. For listed companies, the concentration of equity of the first controlling shareholder plays a very important role in the process of information disclosure monitoring, and the same is true for carbon accounting information disclosure. According to the principal-agent theory, the higher the degree of centralization of controlling shareholders, the higher the requirements for fiduciary management. When the concentration of equity of the first controlling shareholder is higher, it can produce a stronger centralization threshold, which can effectively bring high-quality decision-making services to the enterprise and form effective supervision of the group enterprise, resulting in a higher disclosure component of carbon accounting by the management. Conversely, when the equity concentration is low, the more obvious the constraining power is, the greater the possibility of management concealing carbon accounting information.

5 Conclusions

Through empirical research and analysis, it can be concluded that the overall level of environmental accounting information disclosure in China's chemical industry is at a medium level in the past four years, but the level of carbon accounting information disclosure varies among enterprises and there are certain gaps. Checking the data, we found that the carbon accounting information disclosure of listed companies in China's chemical industry is mainly based on qualitative descriptions such as texts, including what measures enterprises have taken to reduce environmental pollution, but few quantitative descriptions such as data indicators. Meanwhile, enterprises may disclose selectively, and to improve their social image in front of the public, they are more inclined to disclose information that is favorable to them and hide information that is unfavorable to them.

For the same industry, a unified environmental accounting information disclosure standard should be established for regulation, and the important contents of carbon accounting information that should be disclosed every year should be strictly regulated, so that enterprises can make horizontal comparisons among different enterprises in the same industry based on vertical comparisons in different periods [10]. Relevant legal norms should be continuously improved and relevant policies should be implemented to make enterprises realize the mandatory and binding nature of carbon accounting information disclosure. In addition, the government and other relevant institutions should also take measures to strengthen the overall supervision of the disclosure of carbon accounting information by enterprises. Enterprises that fail to disclose information as required can be punished accordingly.

Carbon accounting information disclosure is not only to help investors to make reasonable decisions but also a written commitment for enterprises to take social responsibility. As environmental problems become more and more serious, we should all do our

best to protect and improve the environment. As a large social group, companies will have a greater impact on the environment than each of us citizens. Therefore, companies should take active measures to reduce the environmental impact of their daily activities, especially in highly polluting industries such as chemicals. If enterprises make efforts to take measures to improve the environment, the actual results should be announced to society. At the same time, the awareness of corporate social responsibility should be actively cultivated so that enterprises can disclose environmental accounting information actively and proactively.

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