Research on the Impact of Environmental Information Disclosure on Financial Performance

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Abstract. In the current global context of escalating environmental concerns, it has become increasingly crucial for enterprises to disclose environmental information in order to effectively communicate their environmental performance and risk management with external stakeholders. This is particularly pertinent for publicly traded companies in heavily polluting industries, as the disclosure of environmental information not only impacts corporate reputation and image, but also directly affects their financial sustainability. Therefore, this study aims to investigate the influence of environmental information disclosure on the financial performance of publicly traded companies in heavily polluting industries, while also examining how property rights moderate this relationship. Drawing from previous research, this paper presents corresponding research hypotheses and constructs a comprehensive research model. The empirical analysis serves as the primary research method, allowing for an in-depth exploration of sample data to uncover the intricate connection between environmental information disclosure and financial performance within heavily polluting industries, as well as how property rights factor into this dynamic. Ultimately, this study contributes to enhancing our theoretical understanding of the link between environmental information disclosure and corporate financial performance, providing a scientific basis for government policy formulation and offering practical guidance for listed companies in heavily polluting industries seeking to improve both their financial sustainability and environmental performance.

Keywords: Environmental information disclosure, Financial performance, Heavy polluting enterprises, Dual carbon goals.

1. Introduction

In 2020, China formally proposed the targets of reaching a carbon peak and achieving carbon neutrality. China aims to reach the peak of carbon dioxide emissions by 2030 and strive for carbon neutrality by 2060. The environmental performance of heavy-polluting enterprises has attracted significant attention, with environmental information disclosure serving as a crucial tool for government, investors, consumers, and other stakeholders to gain a comprehensive understanding of the environmental impact of these enterprises in order to effectively monitor their activities. From the perspective of meeting the dual carbon goals, the disclosure of environmental information by heavy polluting enterprises plays a pivotal role in achieving these objectives. The primary objective of enterprise operations is profit generation, with financial performance serving as a key indicator for measuring profitability. It can be argued that financial performance directly influences the environmental behavior of enterprises. Therefore, studying how levels of environmental information disclosure impact financial performance holds substantial practical significance as it not only encourages enterprises to actively fulfill their environmental responsibilities and strengthen their management practices but also promotes green investment development and provides a scientific basis for policy formulation in order to collectively advance society's green and sustainable development process.

Currently, numerous scholars have researched the significance and enhancement of environmental information disclosure systems. Buhr discovered that most companies provide incomplete and low-quality environmental information disclosure, with a simplistic approach to the disclosure process. It is suggested that companies should engage in comprehensive disclosure of relevant information through specialized environmental reports [1].Zhang et al. (2021) underscored the pivotal role of the government in fostering the establishment of environmental information disclosure systems and

highlighted that enhancing social responsibility disclosure mechanisms is crucial for prompting enterprises to actively fulfill and comprehensively disclose their social responsibilities. Bolstering governmental guidance and oversight in the construction of environmental information disclosure systems holds far-reaching implications for promoting corporate social responsibility fulfillment and elevating public trust in enterprises [2]. Zhao et al. conducted a study using heavily polluting A-share listed companies as samples, investigating the relationship between environmental information disclosure scores and corporate performance levels. The results revealed a significant positive correlation between the two. Furthermore, the study also demonstrated that executives' political backgrounds and ages played a positive moderating role in this positive relationship [3]. In addition, research by He et al. highlighted that enhancing the quality of environmental information disclosure can not only attract external investment, promote technological innovation, and optimize internal management processes but also enhance consumer acceptance of products, thereby strengthening the company's economic performance [4]. These empirical research findings have confirmed the positive impact of environmental information disclosure on corporate financial performance from different perspectives, providing robust evidence to support research in related fields.

Drawing on sustainable development theory, ecological economics, and symbiosis theory, Shu et al. conducted a comprehensive analysis of the symbiotic relationship between the enterprise environmental system and the financial system and introduced the concept of integrating environmental performance with financial performance [5]. They argued that active disclosure of environmental information can enhance enterprise environmental performance, leading to improved financial performance. This perspective underscores the interconnectedness of environmental and financial performance, offering theoretical support for enterprises to achieve both environmental and economic success in practice. Danisch's study has validated a positive association between the disclosure of environmental information and environmental performance. By fully disclosing environmental information, companies can mitigate information asymmetry to some extent, reduce agency costs, and thereby contribute positively to the sustainable development of enterprises, promoting their more stable and long-term growth [6]. The factors that influence an enterprise's disclosure of environmental information are a key area of interest for researchers. According to Latif, important factors affecting environmental disclosure policies include board diversity, profitability, and the political values of shareholders. Additionally, external influences such as a supportive institutional environment, pressure from stakeholders, and strong internal and external governance mechanisms have a significant impact on the quality of an enterprise's environmental information disclosure [7].Aerts et al. discovered that shareholder behavior creditors' actions social investors can influence companies' decisions regarding their level of transparency in disclosing their environmentally-related activities [8]. Liao et al., through an empirical study using multiple linear regression found that senior executives gender proportion independent directors board directors affect company's decision disclose its environmentally related activities [9] Fath, found company size economic development level location corporate financial performance affect company's decision disclose its environmentally related activities [10].

2. Research Hypothesis and Design

Based on the aforementioned analysis, this paper posits the following hypotheses:

Hypothesis H1: There exists a positive correlation between environmental information disclosure and the financial performance of listed companies in heavily polluting industries.

Hypothesis H2: In comparison to state-owned enterprises within heavily polluting industries, non-state-owned listed companies demonstrate a more significant positive impact of environmental information disclosure on their financial performance.

2.1. Variable Selection

(1) Dependent Variable: This study selects the return on assets (ROA) of enterprises as a measure of their financial performance.

(2) Independent Variable: The independent variable in this paper is the quality of environmental information disclosure by enterprises. Drawing from Kong Dongmin's research methodology, this paper utilized the environmental research database within the CSMAR database, categorizing companies' environmental information disclosure based on whether it is monetized or not. Following Wiseman's approach for monetized information, a value of 2 was assigned to combined quantitative and qualitative disclosures, a value of 1 to qualitative disclosures, and a value of 0 to non-disclosure. The specific scoring criteria for environmental information disclosure are presented in Table 1.

Table 1. Scoring Criteria for Environmental Information Disclosure Index

Type of Disclosure	Item of Disclosure	Scoring Description
Environmental management disclosure	Environmental protection concept environmental goals environmental management system environmental education and training special environmental actions emergency mechanisms for the environment environmental honors or awards the "Three Simultaneities" system	Disclosure: 2 points Non-disclosure: 0 points
Environmental certification disclosure	Has the company been certified with ISO14001? Has the company been certified with ISO9001?	Yes: 2 points No: 0 points
Carrier of environmental information disclosure	Listed Company Annual Report, Corporate Social Responsibility Report Environmental Report	Disclosure: 2 points Non-disclosure: 0 points
Environmental liability disclosure	Wastewater emissions COD emissions SO2 emissions CO2 emissions Soot and dust emissions Industrial solid waste emissions	Quantitative and qualitative description: 2 points Qualitative only: 1 point None: 0 points
Environmental performance and governance disclosure	Emission control of waste gases reduction and treatment of wastewater discharge management of dust and soot emissions utilization and disposal of solid waste, Noise, light pollution, radiation treatment Implementation of cleaner production	

2.2. Control Variables

This paper will select a series of control variables, including the proportion of fixed assets (FIXED), cash flow ratio (Cashflow), total assets turnover (ATO), operating income growth rate (Growth), and establishment years (FirmAge) to more comprehensively analyze the motivation of environmental information disclosure (Table 2).

Table 2. Variable definition table

Variable Type	Variable Abbreviation	Variable Name	Variable Definition
Dependent Variable	ROA	Return on Total Assets	Net Profit/Total Assets
Independent Variable	Eidq	Environmental Information Disclosure Index	ln(Total Score + 1)
	Lev	Debt-to-Asset Ratio	End-of-Year Total Liabilities/End-of-Year Total Assets
	Indep	Proportion of Independent Directors	The proportion of Independent Directors to the Board Size
	Top1	Shareholding Percentage of the Largest Shareholder	Shareholding Ratio of the Largest Shareholder to Total Shares
	Board	Number of Board Members	ln(Number of Directors)
Control Variable	FIXED	Proportion of Fixed Assets	Net Fixed Assets/Total Assets
	Cashflow	Cash Flow Ratio	Net Cash Flow from Operating Activities/Total Assets
	FirmAge	Company Establishment Age	ln(Current Year - Company Establishment Year + 1)
	ATO	Total Asset Turnover Rate	Operating Income/Average Total Assets
Moderating Variable	SOE	Property Ownership Nature	State-owned Enterprise=1, Non-state-owned Enterprise=0

2.3. Model Specification

This study incorporates the asset-liability ratio, proportion of independent directors, shareholding percentage of the largest shareholder, number of directors, proportion of fixed assets to total assets, cash flow ratio, company establishment age, and total asset turnover rate as control variables. The return on total assets is selected as the dependent variable and the environmental information disclosure index is the explanatory variable. To test Hypothesis H1, this paper formulates the following baseline regression Model (1):

$$ROA_{i,t}=a_0+a_1Eidq_{i,t}+a_2Lev_{i,t}+a_3Indep_{i,t}+a_4Top1_{i,t}+a_5Board_{i,t}+a_6FIXED_{i,t}+a_7Cashflow_{i,t}+a_8FirmAge_{i,t}+a_9ATO_{i,t}+\varepsilon \quad (1)$$

In order to verify Hypothesis H2, SOE, and its cross-product Eidq*SOE are added to the benchmark regression model, and the following Model (2) is constructed:

$$ROA_{i,t}=a_0+a_1Eidq_{i,t}+a_2Eidq_{i,t}*SOE_{i,t}+a_3SOE_{i,t}+a_4Lev_{i,t}+a_5Indep_{i,t}+a_6Top1_{i,t}+a_7Board_{i,t}+a_8FIXED_{i,t}+a_9Cashflow_{i,t}+a_{10}FirmAge_{i,t}+a_{11}ATO_{i,t}+\varepsilon \quad (2)$$

2.4. Data Collection

This study focuses on A-share listed companies in heavy pollution industries from 2013 to 2022. The selection of the 16 heavy pollution industries is based on industry classification guidelines by the China Securities Regulatory Commission and environmental verification directories established by

the Ministry of Environmental Protection. The data was sourced from CSMAR database, with a final sample size consisting of 1370 listed companies and 8706 valid observations after excluding samples that were ST or PT during this year or had significant data defects.

3. Empirical Analysis

3.1. Descriptive Statistics

As shown in Table 3, the environmental information disclosure index (Eidq) of listed companies in China's heavy pollution industry was relatively low from 2013 to 2022. The minimum value of the environmental information disclosure index is 0, the maximum value is 3.638, the average value is 2.488, the median value is 2.708, and the standard deviation is 0.837. According to the definition of the environmental information disclosure index in this study, its maximum possible value is 3.932; a higher score indicates a greater degree and quality of environmental information disclosure by enterprises. The minimum financial performance (ROA) for listed companies in the heavy pollution industry is -0.236, while the maximum value is 0.255; this wide range suggests uneven development among heavy polluting enterprises with an average ROA of 0.0496, a median ROA of 0.0448, and a standard deviation of 0.0660.

Table 3. Descriptive statistics

Variables of interest	Mean	Max	Standard deviation	Median number	Min
Eidq	2.488	3.638	0.837	2.708	0
ROA	0.0496	0.255	0.0660	0.0448	-0.236
Lev	0.396	0.927	0.200	0.383	0.0462
Top1	0.344	0.755	0.147	0.321	0.0860
Indep	0.373	0.571	0.0506	0.333	0.313
Board	2.137	2.708	0.193	2.197	1.609
FIXED	0.289	0.719	0.158	0.265	0.0255
Cashflow	0.0625	0.266	0.0651	0.0608	-0.160
ATO	0.668	2.891	0.396	0.591	0.0847
FirmAge	2.974	3.611	0.290	2.996	1.792

3.2. Correlation analysis

The correlation analysis was conducted to examine the relationship between financial performance (ROA) and environmental information disclosure index (Eidq), along with eight control variables. As presented in Table 4, the correlation coefficient between financial performance (ROA) and the environmental information disclosure index (Eidq) is 0.072, which is statistically significant at the 0.05 level, indicating a substantial positive association between financial performance and environmental information disclosure. The findings support hypothesis H1 by demonstrating that more comprehensive environmental information disclosure leads to higher financial performance among listed companies in heavily polluting industries. Additionally, financial performance exhibits negative correlations with asset-liability ratio, total asset turnover, shareholding ratio of the largest shareholder, number of directors, proportion of fixed assets, and company establishment years. Furthermore, there is a significant positive correlation between financial performance and cash flow ratio as indicated by a correlation coefficient of 0.059 with a p-value <0.01. Conversely, there is no discernible correlation between financial performance and independent director ratio as evidenced by a close-to-zero correlation coefficient of -0.0140 with a p-value>0.

Table 4. Correlation analysis

	Eidq	ROA	Lev	Top1	Indep	Board	FIXED	Cashflow	ATO	FirmAge
Eidq	1									
ROA	0.072***	1								
Lev	0.085***	-0.441***	1							
Top1	0.111***	0.071***	0.073***	1						
Indep	-0.018*	-0.0140	-0.00200	0.039***	1					
Board	0.115***	-0.043***	0.190***	0.0160	-0.540***	1				
FIXED	0.113***	-0.206***	0.385***	0.136***	-0.024**	0.156***	1			
Cashflow	0.122***	0.509***	-0.170***	0.102***	-0.00500	0.028***	0.138***	1		
ATO	0.124***	0.190***	0.071***	0.074***	0.0150	-0.0120	-0.051***	0.126***	1	
FirmAge	0.117***	-0.068***	0.135***	-0.094***	-0.00500	0.049***	0.097***	0.038***	0.0130	1

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

3.3. Test of Collinearity

The VIF values for all variables are below 5, indicating the absence of any significant collinearity issues in the model (Table 5).

Table 5. Test of collinearity

	VIF	1/VIF
Eidq	1.340	0.745
Lev	1.470	0.680
Top1	1.170	0.851
Indep	1.480	0.674
Board	1.630	0.615
FIXED	1.620	0.619
Cashflow	1.200	0.831
ATO	1.370	0.732
FirmAge	1.300	0.767
Mean	VIF	1.660

3.4. Hausman Test

According to the results of the Hausman test, the fixed effect model is deemed appropriate. Therefore, all regression results reported in this paper are based on fixed effect estimation. Robust standard errors are used in the estimation process of the fixed effect model while controlling for industry and time fixed effects.

3.5. Regression Analysis

3.5.1 Findings from benchmark regression analysis

As depicted in Table 6, the regression coefficient for the Environmental Information Disclosure Index (Eidq) is 0.00351, with a significance level of 0.01. This suggests that environmental information disclosure has a statistically significant positive impact on financial performance, thus providing support for Hypothesis H1.

Table 6. Findings from benchmark regression analysis

	ROA
Eidq	0.00351***
	(4.87)
Lev	-0.105***
	(-33.21)
Top1	0.0257***
	(6.69)
Indep	0.000775
	(0.06)
Board	0.00883*
	(2.57)
FIXED	-0.0722***
	(-17.27)
Cashflow	0.443***
	(50.49)
ATO	0.0299***
	(19.45)
FirmAge	-0.00637**
	(-3.11)
cons	0.0407**
	(3.24)
N	8706
F	158.11
R^2	0.4619
ind	YES
year	YES

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The values of t are enclosed in parentheses.

3.5.2 Regression analysis of property right adjustment effect

In order to thoroughly investigate the influence of environmental information disclosure on the financial performance of enterprises with different ownership rights, this study categorizes the sample companies into two groups based on their ownership: state-owned and non-state-owned. Specifically, for state-owned enterprises in heavily polluting industries, we assign a value of 1 to the SOE variable; for non-state-owned enterprises, the SOE variable is set to 0. In our benchmark regression model, we

introduce the SOE variable and its interaction term with Eidq (Eidq*SOE) to examine their effects on financial performance through regression analysis. The detailed results are presented in Tables 4-6. Upon careful analysis of the data in Tables 4-6, we observe that the regression coefficient for Eidq is 0.00467 and statistically significant at a level of significance of 0.01, indicating a positive impact of environmental information disclosure on financial performance. Additionally, the regression coefficient for Eidq*SOE on ROA is -0.00296 and significant at a level of significance of 1%, suggesting that compared to state-owned heavily polluting enterprises, environmental information disclosure has a more pronounced effect on financial performance for non-state-owned heavily polluting enterprises. This finding provides strong support for hypothesis H2.

Table 7. Regressional findings on the moderating impact of property rights

	ROA
Eidq	0.00467***
	(6.27)
Eidq*SOE	-0.00296***
	(-5.98)
Lev	-0.103***
	(-32.46)
Top1	0.0300***
	(7.69)
Indep	0.00644
	(0.51)
Board	0.0122***
	(3.51)
FIXED	-0.0685***
	(-16.24)
Cashflow	0.441***
	(50.34)
ATO	0.0303***
	(19.72)
FirmAge	-0.00427*
	(-2.06)
cons	0.0245
	(1.91)
N	8706
F	156.18
R^2	0.4641
ind	YES
year	YES

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The values of t are enclosed in parentheses.

3.6. Robustness Test

3.6.1 Benchmark regression robustness test

(1) Replacement of financial performance measures

The paper further tests the reliability of the conclusions by replacing the index of return on total assets (ROA) with the index of return on equity (ROE) in Model (1) for regression. The results, shown in Table 8, indicate that the coefficient of the environmental information disclosure index (Eidq) is greater than 0 and significant within the 0.01 level, suggesting that the results of the benchmark regression are reliable.

Table 8. Robustness test

	ROE
Eidq	0.00853***
	(5.37)
Lev	-0.143***
	(-20.56)
Top1	0.0476***
	(5.61)
Indep	0.0583*
	(2.11)
Board	0.0358***
	(4.72)
FIXED	-0.103***
	(-11.11)
Cashflow	0.751***
	(38.84)
ATO	0.0635***
	(18.71)
FirmAge	-0.0136**
	(-3.02)
cons	-0.0303
	(-1.09)
N	8706
F	86.89
R^2	0.3205
ind	YES
year	YES

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

The values of t are enclosed in parentheses.

(2) The analysis of the environmental information disclosure index lagged by one period

In order to further validate the reliability of the findings, Model (1) regresses the independent variable environmental information disclosure index (Eidq) with a one-lag. The table reveals that the coefficient of L.Eidq is 0.00236 after one lag, which is statistically significant at the 0.05 level and consistent with the benchmark regression, indicating the reliability of H1 (Table 9).

Table 9. The regression results show the impact of independent variables lagged by one period

	ROA
L.Eidq	0.00236**
	(3.08)
Lev	-0.104***
	(-29.70)
Top1	0.0251***
	(5.93)
Indep	0.0122
	(0.89)
Board	0.0133***
	(3.55)
FIXED	-0.0676***
	(-14.76)
Cashflow	0.444***
	(45.44)
ATO	0.0286***
	(16.91)
FirmAge	-0.00574*
	(-2.44)
cons	0.0229
	(1.66)
N	7296
F	127.15
R^2	0.4465
ind	YES
year	YES

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The values of t are enclosed in parentheses.

3.6.2 Regressional analysis on the impact of property rights adjustment

In order to further validate the reliability of the moderating effect regression, this paper replaces the explained variable of return on total assets (ROA) with the index of return on equity (ROE) in Model (2) for regression analysis. The results show that the coefficient of Eidq is greater than 0 and significant at the 1% level, supporting H1. Additionally, in Model (2), the regression coefficient of Eidq*SOE on ROE is -0.00479, and it is significant at the 0.01 level, indicating that non-state-owned heavy polluting enterprises have a more substantial impact on financial performance through environmental information disclosure compared to state-owned counterparts, thus confirming Hypothesis H2 (Table 10).

Table 10. The robustness test for regression on the moderating impact of property rights

	ROE
Eidq	0.0104***
	(6.33)
Eidq*SOE	-0.00479***
	(-4.37)
Lev	-0.140***
	(-20.01)
Top1	0.0546***
	(6.33)
Indep	0.0674*
	(2.43)
Board	0.0412***
	(5.37)
FIXED	-0.0966***
	(-10.36)
Cashflow	0.748***
	(38.69)
ATO	0.0641***
	(18.89)
FirmAge	-0.0102*
	(-2.24)
cons	-0.0565*
	(-1.99)
N	8706
F	85.66
R^2	0.3220
ind	YES
year	YES

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The values of t are enclosed in parentheses..

4. Suggestion

4.1. Guidance for Governmental Departments

In order to effectively promote the legal reform of the environmental information disclosure system, the government must further enhance interconnection between systems, strengthen capacity building, and conduct continuous follow-up evaluations to ensure steady progress in the reform task.

Firstly, it is necessary to improve the management system of the environmental information disclosure system and establish detailed management procedures and standard requirements for lawful environmental information disclosure.

Secondly, in order to incentivize enterprises, the government should provide certain benefits to heavily polluting enterprises that demonstrate good performance in disclosing environmental information. This can be achieved through preferential policies such as government subsidies or other measures aimed at reducing their environmental compliance costs and thereby increasing their motivation for disclosure.

Furthermore, a continuous tracking and evaluation mechanism for environmental information disclosure needs to be established by the government to strengthen monitoring and assessment of implementation. This includes conducting rigorous audits and inspections to ensure the authenticity and comparability of disclosed information. Additionally, heavy polluting enterprises should be required to disclose non-confidential production facilities, technological processes, pollution control facilities, as well as emission data. Alongside enhanced legal or administrative supervision, proactive fulfillment of environmental responsibilities should be rewarded while penalties for ecological damage behaviors are increased. Investment institutions should also be encouraged to prioritize attention on environmental information disclosure.

Finally, governmental departments need to enhance coordination and cooperation in order to collectively drive enterprise environmental information disclosure implementation forward. Given that oversight of this process involves multiple governmental bodies, all regulatory departments should jointly shoulder supervisory responsibilities by forming a united front. Simultaneously establishing an open and transparent platform for disclosing environmental information is crucial for meeting various regulatory authorities' needs as well as those within society at large. Actively disseminating relevant data through an informational system will provide robust support for constructing a collaborative management mechanism.

4.2. Recommendations for Heavily Polluting Industries

Primarily, it is imperative for heavily polluting enterprises to fully comprehend the significance of environmental information disclosure and integrate it into their strategic planning and daily operations. Enterprises should establish a robust environmental information disclosure system to ensure the accuracy and completeness of environmental data, and promptly disclose pertinent information to the public. This will not only enhance enterprise transparency and image but also bolster investor confidence and attract greater financial support.

Secondly, heavy polluting enterprises should escalate investment in environmental protection and actively enhance environmental performance in the production process. Through the adoption of environmental protection technology, optimization of production processes, and reduction of pollutant emissions, enterprises can minimize environmental costs while improving resource utilization efficiency. This approach will enable enterprises to achieve superior results in environmental protection while enhancing competitiveness and achieving sustainable development.

In addition, heavy-polluting enterprises should strengthen communication and collaboration with government entities, industry associations, and other organizations to collectively promote the enhancement and implementation of an environmental information disclosure system. Enterprises can

actively engage in government-led environmental protection activities, share expertise and technology in this field, as well as advocate for green industry development through participation in industry association initiatives.

Finally, heavy-polluting enterprises should establish an effective internal control mechanism along with a comprehensive risk assessment framework to ensure compliance with authentic environmental information disclosure practices. Enterprises must intensify supervision over the management of their environment-related data dissemination processes in order to prevent distortion or leakage of crucial information.

Furthermore, enterprises must conduct regular risk assessments aimed at identifying potential environmental hazards promptly so as to guarantee smooth operational continuity.

5. Conclusion

The study demonstrates that the disclosure of environmental information has a favorable impact on the financial performance of publicly traded companies operating in heavily polluting industries. There exists a significant positive correlation between financial performance and the index of environmental information disclosure. In comparison to state-owned enterprises in heavily polluting industries, non-state-owned listed companies experience a more pronounced positive effect on their financial performance as a result of environmental information disclosure.

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