Environmental Performance, Debt Financing Cost and Firm Value: A Case Study of Listed Companies in Heavily Polluting Industries

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Abstracts

Background and Aim: As the public becomes more and more sensitive to environmental pollution, they will pay more attention to the environmental protection of enterprises. The high level of environmental performance of enterprises means that enterprises will pay more energy and resources. Simultaneously, stable and sustainable capital supply is an important guarantee for enterprises to obtain sustainable development in market competition; moreover, debt financing cost becomes crucial for enterprises. Lower debt financing cost refers to that enterprises can spend more money for business development and improve the value of enterprises. This research studies the relationship between corporate environmental performance, debt financing cost and corporate value through the data of listed companies in heavily polluting industries from 2011 to 2021.

Materials and Methods: Firstly, the research is designed by using the document research method combined with stakeholder theory, signaling theory, principal-agent theory and other relevant theories; besides, empirical research is conducted through descriptive statistics, correlation analysis and multiple linear regression model.

Results: The environmental performance of listed companies in heavily polluting industries has a significant negative correlation with debt financing costs; environmental performance significantly promotes enterprise value; the cost of debt financing has a significant positive correlation with enterprise value; debt financing cost has intermediary effect on the relationship between environmental performance and enterprise value.

Conclusion: (1) The higher the environmental performance of listed companies in heavily polluting industries, the lower the debt financing cost. (2) There is a significant positive correlation between the environmental performance of listed companies in heavily polluting industries and their enterprise value. (3) There is a positive correlation between the cost of debt financing and the enterprise value of publicly traded polluting industries. The relationship between environmental performance and enterprise value is moderated by the cost of debt financing for publicly traded companies in heavily polluting industries.

Keywords: Heavily Polluting Industries; Environmental Performance; Debt Financing Cost; Enterprise Value

Introduction

China's gross national product has increased since reform and opening up. China's GDP, calculated using purchasing power parity standards, surpassed that of the United States in 2014. At the same time, economic development has resulted in the continuous deterioration of the environment, particularly in heavy pollution industries such as steel and chemical, which have imposed a significant burden on the environment. Heavy polluting industries are the most environmentally sensitive in China's economic system, but they are also the most important in promoting economic growth. However, the industries that use the most resources and pollute the environment are the most polluting. It is clear that the environmental governance of highly polluting industries is linked not only to China's environmental governance, but also to China's economic development (Cho and Patten, 2007; Pattem, 1991; Hanssen et al., 2000).

Enterprises with high levels of environmental performance will pay more for energy and resources. According to statistics, the average lifespan of Chinese businesses is only 3.9 years. In this environment, it is difficult for businesses to use redundant economic resources to improve environmental governance. However, environmental conditions have made it impossible for businesses to continue consuming natural resources without restraint, so it is critical to seek external assistance, such as debt financing. In light of this, this paper will examine the relationship between environmental performance and enterprise value of heavily polluting businesses, as well as the mechanism of debt financing cost between them (Klassen and Melaughlin, 1996; Tang et al., 2021; Tang and Sun, 2021; Li et al., 2015).

Research significance

The study of the relationship between environmental performance, debt financing cost, and enterprise value can provide theoretical support for our government's unwavering implementation of

the "green" policy while also contributing to the theoretical research on improving the environmental performance of Chinese enterprises.

The study of enterprise environmental performance, debt financing cost, and enterprise value can help enterprises improve their environmental governance level, increase their sense of social responsibility, reduce enterprise financing pressure, maintain long-term development ability, and increase enterprise value.

Objectives

The purpose of this paper is to investigate the relationship between environmental performance and enterprise value of heavily polluting businesses, as well as the mechanism of debt financing cost between them. The full text is divided into six sections: (A) Greetings. (B) Review of the literature. Theoretical foundation and concept definition (C). (D) Design and research. (E) Empirical test section. (F) Research findings and managerial implications.

Literature Review and Hypothesis

As a starting point, this paper investigates the impact of environmental performance on the quality of voluntary disclosure of environmental information by enterprises and the promotion of environmental information disclosure level on enterprise value in the capital market, supported by theories of social responsibility, sustainable development theory, stakeholder theory, information asymmetry theory, and voluntary disclosure theory, as well as research methods and conclusions (Porter and Gerry, 2005; Tian, 2010; Shen, 2007).

Hypothesis 1: The environmental performance level of listed enterprises in heavily polluting industries has a significant positive impact on enterprise value.

Hypothesis 2: The environmental performance of listed companies in heavily polluting industries is negatively correlated with the cost of debt financing.

Hypothesis 3: The lower the debt financing cost of listed enterprises in heavily polluting industries, the higher the enterprise value of enterprises.

Hypothesis 4: the debt financing cost of listed companies in heavily polluting industries has an intermediary effect on the relationship between environmental performance and enterprise value. Environmental performance first reduces the debt financing cost, and the reduction of debt financing cost enhances enterprise value.

Research Methodology

1.Sample selection and data sources

This paper is based on the data of listed companies in heavily polluting industries that are sensitive to the environment from 2010 to 2021. In the process of data integration, this paper deals with the data as follows (Liu, 2009; Lin and Ding, 2017): (1) Eliminate that sample with missing value. (2) Eliminate st and *st enterprises. And (3) One Percentage winsor Truncation for Continuous Variables.

The data of environmental performance in this paper comes from the annual report and social responsibility report of enterprises, and the rest comes from csmar database. The software for empirical research in this paper is stata16.0.

2. Variable design

2.1 The explained variable: Enterprise worth (TQ). There are numerous voices in academic circles advocating for the quantification of enterprise value. Some scholars propose that enterprises be valued based on their management level, while others believe that enterprises should be valued based on their financial level. Still others believe that enterprises should be valued based on their performance in the secondary stock market. Tobin Q value is used in this paper to measure the enterprise value of heavily polluted listed enterprises from the standpoint of market value.

2.2 Explanatory variables: Environmental performance (EDI). Through the integration of previous research results, this paper refers to the method of the CSRC in 2007, and evaluates the environmental performance of heavily polluted listed companies from four dimensions: significance,

comparability, reliability and integrity. The total score is 19 points. See Table 4-1 for detailed scoring rules. Finally, this paper divides the total score of heavily polluting enterprises in four dimensions by 19 as a measure of environmental performance, and the index is expressed by the formula:

$$EDI=\frac{\sum_{i=1}^{13} EDI_i}{19}$$

Table 1 Detailed Table of Environmental Performance Scoring

	Indicator setting	Assignment standard
Significance	1. Whether the heavily polluting enterprises issue environmental reports or social responsibility reports.	If the environmental report or social responsibility report is published, the assignment is 1 point, and if it is not published, it will not be scored.
Comparability	2. Does the environmental information disclosure of heavily polluting enterprises contain comparable information?	If the environmental information disclosure has comparability characteristics, it will be assigned as 1 point, and it will not be scored if it is not disclosed.
Reliability	3. Is the heavily polluting enterprise certified by is014001?	If the enterprise passes the is014001 certification, it will be assigned 1 point, and if it fails, it will not be scored.
	4. Does the environmental information disclosure of heavily polluting enterprises include the operation of environmental protection facilities?	If its environmental information disclosure includes the operation of environmental protection facilities, it will be assigned 1 point, and if it does not, it will not be scored.
	5. Does the environmental information disclosure of heavily polluting enterprises disclose environmental policies and objectives?	If its environmental information disclosure contains environmental policies and objectives, it will be assigned 1 point, and if it does not, it will not be scored.
	6. Are heavily polluting enterprises on the list of environmental penalties?	If the heavily polluting enterprise is not on the list of environmental penalties, it will be assigned 1 point, and if it is on the list, it will not be scored.
	7. Does the heavily polluting enterprise have an environmental risk emergency system?	If there is an environmental risk emergency system, the assigned value is 1 point, and if there is no environmental risk emergency system, no score will be given.
Integrity	8. Environmental protection technology development of heavily polluting enterprises	Quantitative disclosure is 2, qualitative disclosure is 1, and no disclosure is scored.

Indicator setting	Assignment standard
9. Environmental subsidies received by heavily polluting enterprises	Quantitative disclosure is 2, qualitative disclosure is 1, and no disclosure is scored.
10. Environmental protection expenditure of heavily polluting enterprises	Quantitative disclosure is 2, qualitative disclosure is 1, and no disclosure is scored.
11. Litigation and administrative punishment of heavily polluting enterprises	Quantitative disclosure is 2, qualitative disclosure is 1, and no disclosure is scored.
12. Pollutant discharge of heavily polluting enterprises	Quantitative disclosure is 2, qualitative disclosure is 1, and no disclosure is scored.
13. Environmental resource consumption of heavily polluting enterprises	Quantitative disclosure is 2, qualitative disclosure is 1, and no disclosure is scored.

2.3 Intermediate variables: The cost of debt financing (debt). After sorting through the financial statements of listed companies in heavily polluting industries, it is discovered that the data disclosure of both interest expenses and interest-bearing liabilities is relatively complete. As a result, the ratio of interest expenses to interest-bearing liabilities is used to calculate the cost of debt financing.

2.4 Control variables: Due to the fact that there are additional variables that will affect the enterprise value, the potential variables controlled in this paper include: financial leverage (lev), audit firm type (Big4), profitability (roa), enterprise growth (age), equity nature (state), and board size, with the specific measurement methods listed in the table below.

Table 2 Variable Measurement Table

Variable	Name	Symbol	Measurement mode
Explained variable	Enterprise value	TQ	Calculated according to the model
Explanatory variable	Environmental performance	EDI	$EDI=\frac{\sum_{i=1}^{13} EDI_i}{19}$
mediator variable	Debt financing cost	DEBT	Interest expense divided by interest-bearing liabilities
Control variable	trading on equity	lev	Asset-liability ratio
	Type of audit firm	Big4	The number of the top four international firms is 1, otherwise it is 0.
	profitability	ROA	return on total assets

Variable	Name	Symbol	Measurement mode
	Time to market	Age	Difference between sample year and listing year of enterprise
	Enterprise growth	Growth	Growth rate of business income of enterprises
	Enterprise nature	state	The assignment of state-owned enterprises is 1, and that of non-state-owned enterprises is 0.
	Board size	board	Natural logarithm of the number of directors

3. Model design

In order to verify hypothesis h1, this paper takes the whole sample as the research sample and constructs model 1:

$$DEBT_{i,\ t}=\beta_0 + \beta_1 EDI_{i,\ t} + \beta_2 LEV_{i,\ t} + \beta_3 ROA_{i,\ t} + \beta_4 BIG4_{i,\ t} + \beta_5 Age_{i,\ t} + \beta_6 State_{i,\ t} + \beta_7 Board_{i,\ t} + \beta_8 Growth_{i,\ t} +\varepsilon,$$

If $\beta 1$ is positive and significant, the h1 hypothesis is verified.

In order to verify the hypothesis h2, this paper takes the whole sample as the research sample and constructs model 2:

$$TQ_{i,\ t}=\beta_0 + \beta_1 DEBT_{i,\ t} + \beta_2 LEV_{i,\ t} + \beta_3 ROA_{i,\ t} + \beta_4 BIG4_{i,\ t} + \beta_5 Age_{i,\ t} + \beta_6 State_{i,\ t} + \beta_7 Board_{i,\ t} + \beta_8 Growth_{i,\ t} +\varepsilon,$$

If $\beta 1$ is positive and significant, the h2 hypothesis is verified.

In order to verify hypothesis h3, this paper takes the whole sample as the research sample and constructs model 3:

$$TQ_{i,\ t}=\beta_0 + \beta_1 EDI_{i,\ t} + \beta_2 LEV_{i,\ t} + \beta_3 ROA_{i,\ t} + \beta_4 BIG4_{i,\ t} + \beta_5 Age_{i,\ t} + \beta_6 State_{i,\ t} + \beta_7 Board_{i,\ t} + \beta_8 Growth_{i,\ t} +\varepsilon,$$

If $\beta 1$ is negative and significant, the h2 hypothesis is verified.

In order to verify hypothesis h3, this paper takes the whole sample as the research sample and constructs model 4:

$$TQ_{i,\ t}=\beta_0 + \beta_1 EDI_{i,\ t} + \beta_2 DEBT_{i,\ t} + \beta_3 LEV_{i,\ t} + \beta_4 ROA_{i,\ t} + \beta_5 BIG4_{i,\ t} + \beta_6 Age_{i,\ t} + \beta_7 State_{i,\ t} + \beta_8 Board_{i,\ t} + \beta_9 Growth_{i,\ t} +\varepsilon,$$

If $\beta 1$ is significant in model 1 and $\beta 2$ is significant in model 4, the h3 hypothesis is verified.

In all the above models, $\beta 0$ is a constant term, $\beta 1$-9 is a regression coefficient, and ε is a residual coefficient. T stands for reporting year, and I stands for enterprise.

Empirical Results and Analysis
1.Descriptive statistics

First, make descriptive statistics on the main variables, and the results are shown in Table 5-1:

Table 3 Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	Max
TQ	7, 606	2.507	1.748	0.846	10.230
EDI	7, 606	0.746	0.123	0	1.000
DEBT	7, 606	0.048	0.050	0	0.292
Lev	7, 606	0.399	0.205	0.045	0.878
Growth	7, 606	0.165	0.350	-0.449	2.197
ROA	7, 606	0.049	0.061	-0.161	0.228
Board	7, 606	2.285	0.241	1.609	2.890
TOP1	7, 606	0.354	0.148	0.091	0.771
Age	7, 606	16.819	5.399	4.000	31.000
State	7, 606	0.348	0.476	0.000	1.000

The enterprise value (tq) reaches a maximum of 10.230 and a minimum of 0.846%. The specific differences between the extreme values indicate that there will be substantial differences between the enterprise values of listed companies in various heavily polluting industries, and the differences in dependent variable data provide the conditions for examining the factors that influence enterprise value. The average value of environmental performance (edi) is 0.746%, indicating that the current environmental performance of heavily polluting listed enterprises in China must be enhanced in order to maintain a certain level. The average debt financing cost (Debt) is 0.048, equating to an annual debt financing cost of 4.8% of interest-bearing liabilities for listed companies in heavily polluting industries in China. The minimum value in the sample is 0, indicating that there is no financing pressure on the enterprise, while the maximum value is 0.292, indicating that the enterprise has paid a high price for debt financing.

2. Correlation analysis

On the one hand, this part preliminarily verifies the correlation between variables, so as to preliminarily verify whether the selection of variables is reasonable. See Table 5-2 for the specific analysis results:

Table 4 Correlation analysis table

	TQC	EDI	DEBT	Lev	Growth	ROA	Board	TOP1	Age	State
TQC	1									
EDI	0.0242**	1								
DEBT	-0.3079***	-0.013	1							
Lev	-0.3635***	-0.0307***	0.1761***	1						
Growth	0.0875***	-0.0099	-0.0271**	-0.0006	1					
ROA	0.3398***	0.0143	-0.1607***	-0.4773***	0.2646***	1				
Board	-0.0963***	-0.037***	0.0482***	0.1861***	-0.0003	-0.1066***	1			
TOP1	-0.0803***	0.0067	0.0286**	0.0735***	0.0079	0.0722***	0.0113	1		
Age	-0.0563***	-0.1105***	0.016	0.1362***	-0.0817***	-0.0918***	0.0473***	-0.1431***	1	
State	-0.2409***	-0.0357***	0.0885***	0.3413***	-0.073***	-0.1918***	0.2433***	0.2132***	0.1152***	1

The Pearson correlation coefficient between enterprise value (tq) and environmental performance (edi) is 0.0242, and the P value is less than 0.05, indicating a significant positive correlation between the two variables. Enterprise value and debt financing cost are significantly negatively correlated, as their Pearson coefficient is -0.3079 and their P value is less than 0.01, indicating a negative correlation. Both hypotheses h1 and h2 have been provisionally confirmed. In addition, the values of the correlation coefficients between enterprise value (tq) and enterprise value and financial leverage (lev), enterprise profitability (roa), enterprise growth (big4), enterprise age (age), and enterprise nature (state) are -0.3635, 0.0875, 0.3398, and -respectively.

3. Multiple collinearity test

Next, the model is tested for multicollinearity, and the results are as follows:

Table 5 VIF collinearity test

Variable	VIF	1/VIF
Lev	1.4	0.714134
ROA	1.27	0.79049
State	1.24	0.804566
TOP1	1.1	0.910151
Board	1.08	0.922882
Age	1.07	0.936969
Growth	1.02	0.984412
EDI2	1.01	0.986519
DEBT	1.01	0.991387
Mean VIF	1.13	

This part uses VIF values to test multicollinearity. If all VIF values of explanatory variables are less than 10, the model has no multicollinearity problem. The maximum VIF value in the above table is 1.4, far less than 10, so it can be judged that there is no multicollinearity problem in the model setting in this paper.

4. Regression analysis

Table 6 Regression Results Table

Variables	Model 1	Model 2	Model 3	Model 4
Edi	0.174**	-0.006**		0.136
	(2.26)	(-2.20)		(1.01)
Debt			-6.747***	-6.742***
			(-20.81)	(-20.80)
Lev	-1.564***	0.025***	-1.400***	-1.396***
	(-15.45)	(7.13)	(-14.19)	(-14.14)
Growth	0.125**	0.001	0.131***	0.131***
	(2.48)	(0.50)	(2.67)	(2.67)
Roa	5.989***	-0.081***	5.449***	5.444***
	(18.11)	(-7.09)	(16.88)	(16.87)
Board	-0.104	0.003	-0.089	-0.087
	(-1.45)	(1.02)	(-1.27)	(-1.25)
Top1	-0.194	0.006	-0.156	-0.156
	(-1.58)	(1.32)	(-1.31)	(-1.31)
Age	0.012***	0.000	0.011***	0.012***
	(3.17)	(0.00)	(3.24)	(3.26)
State	-0.439***	0.003*	-0.421***	-0.420***
	(-10.81)	(1.94)	(-10.65)	(-10.64)
Constant	3.707***	0.031***	4.027***	3.917***
	(17.06)	(4.16)	(22.17)	(18.52)

Variables	Model 1	Model 2	Model 3	Model 4
Year	control	control	control	control
Industry	control	control	control	control
Observations	7,606	7,606	7,606	7,606
R-Squared	0.343	0.056	0.379	0.379
r2_a	0.340	0.0518	0.376	0.376
f	107.0	12.23	124.7	121.5

The significance levels of 1%, 5% and 10% in the figure are indicated by * * *, * * and * respectively.

According to the model-regression results, the regression coefficient of environmental performance (EDI) and enterprise value (tq) is 0.174, the t value is 2.26, and it passed the significance test at the 1% level (P value is less than 0.01). Assuming that h1 is true, when the environmental performance of listed enterprises in heavily polluting industries improves, enterprise value increases proportionally.

Assuming that h2 is valid, the results of model 2 indicate that the regression coefficient of environmental performance (edi) is -0.006, the t value is -2.20, and P is less than 0.05.

According to the results of the model's trilinear regression, there is a negative correlation between debt financing cost (Debt) and enterprise value (tq), and the regression coefficient is -6,747, which passed the significance test at the 1% level. Assuming h3 is validated, the enterprise value evaluation of heavily polluting publicly traded companies decreases as their debt financing costs increase.

As for the intermediary effect test of debt financing cost (Debt), model 2 demonstrates a significant relationship between environmental performance (edi) and debt financing cost (tq) (p0.05), with a regression coefficient of -0.006. In this model, environmental performance and debt financing cost are negatively correlated. The debt financing cost (Debt) exhibits a significant negative correlation with the enterprise value in the fourth model (t=-20.80, p0.01). When the regression coefficient of environmental performance (edi) in model 3 is significant, but the regression coefficient of environmental performance (edi) in model 4 is not, it indicates that debt financing cost (Debt) as an intermediary variable has an intermediary effect, and that its intermediary effect is a complete intermediary effect. Environmental performance reduces the cost of debt financing before increasing enterprise value.

5. Robustness test

IIn order to avoid the contingent nature of the preceding empirical results, this section tests the robustness by substituting the core variables in order to increase the study's credibility. Referencing Hu Shangguo's (2015) practice, this paper replaces the environmental performance, selects three aspects: environmental certification, environmentally friendly enterprise evaluation, and pollution accident to evaluate the environmental performance level of heavily polluted listed enterprises, and incorporates them into Models 1 through 4 for robustness testing. The results pass the robustness test if they are consistent with the previous results. The following are the results:

Table 7 Robustness Test Table

VARIABLES	(1) TQ	(2) DEBT	(3) TQ	(4) TQ
EDI2	0.016***	-0.001***		0.015
	(3.59)	(-3.57)		(0.63)
DEBT			-0.806**	-0.809**
			(-3.41)	(-2.42)
Lev	-2.027***	0.016***	-2.040***	-2.040***
	(-16.92)	(3.90)	(-17.02)	(-17.02)
State	-0.487***	0.002	-0.489***	-0.488***
	(-9.96)	(1.23)	(-10.00)	(-9.99)
Age	0.004	-0.000	0.004	0.004
	(1.03)	(-0.67)	(0.99)	(1.05)
TOP1	-0.650***	-0.008	-0.644***	-0.643***
	(-4.46)	(-1.58)	(-4.42)	(-4.41)
Board	-0.029	0.006*	-0.035	-0.034
	(-0.33)	(1.89)	(-0.39)	(-0.38)
ROA	4.167***	-0.033***	4.195***	4.194***
	(12.89)	(-2.93)	(12.97)	(12.97)
Growth	0.009	-0.000	0.009	0.009
	(0.88)	(-0.10)	(0.87)	(0.88)
Constant	3.526***	0.042***	3.519***	3.492***
	(15.64)	(5.42)	(15.87)	(15.46)
Industry fixed effect	Control	Control	Control	Control
Year fixed effect	Control	Control	Control	Control
Observations	7, 606	7, 606	7, 606	7, 606
R-squared	0.140	0.009	0.140	0.140
r2_a	0.139	0.00757	0.139	0.139
F	154.1	8.250	154.9	137.7

The significance levels of 1%, 5% and 10% in the figure are indicated by * * *, * * and * respectively.

These results are consistent with the above empirical results, which means that the empirical part of this paper has passed the robustness test.

Conclusion, Discussion and Recommendations
This paper uses the data of listed companies in heavily polluting industries from 2011 to 2021 as data samples, sorts previous studies through literature research, formulates hypotheses based on relevant theories, conducts research design, and empirically verifies the hypotheses, and then concludes: (1) The higher the environmental performance of listed companies in heavily polluting industries, the lower the

debt financing cost o (2) There is a significant positive correlation between the environmental performance of listed companies in heavily polluting industries and their enterprise value. (3) There is a positive correlation between the cost of debt financing and the enterprise value of publicly traded polluting industries. The relationship between environmental performance and enterprise value is moderated by the cost of debt financing for publicly traded companies in heavily polluting industries.

After studying the relationship among environmental performance, debt financing level and enterprise value of listed enterprises in heavily polluting industries in China, this part combines China's national conditions and market conditions, and carries out management enlightenment from the perspective of enterprises in heavily polluting industries, including: (1) Pay attention to environmental information disclosure and enhancing the environmental reputation of enterprises. (2) Enhance the level of environmental management through relevant environmental certification. (3) Increase the corresponding environmental expenditure and promote technological innovation.

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