

Original Research

The Effect and Mechanism of ESG Performance on Corporate Debt Financing Costs: Empirical Evidence from Listed Companies in the Heavy-Polluting Industries

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Abstract

This study investigates the potential benefits of positive environmental, social, and governance (ESG) performance for enterprises operating in heavily polluting industries. Regression analyses using Stata were conducted on a sample of A-share listed enterprises in these industries from 2010 to 2020. The findings reveal that higher ESG performance leads to lower debt financing costs. Furthermore, the analysis of mechanisms indicates that the green innovation behavior of enterprises enhances the impact of ESG performance on debt financing costs. Heterogeneity analysis demonstrates that the ESG performance of heavily polluting enterprises in central China has a more significant influence on debt financing costs. For non-state-owned heavily polluting enterprises, the relationship between standard audit opinions is substantial, as audit opinions contain sufficient information and risk disclosure. This study contributes to our understanding of the economic implications of ESG performance and provides valuable evidence supporting enterprises in their efforts to improve ESG performance.

Keywords: ESG performance, cost of debt financing, green innovation, Stakeholders, environmental regulation

Introduction

In today's global development context, the focus has shifted from high-speed to high-quality. Achieving carbon peak and carbon neutrality plays a crucial role in addressing resource and environmental constraints

and is an inevitable choice for building a strong, modern socialist country. In this new economic landscape, traditional financial reports no longer meet the information needs of users. To reduce information asymmetry, the United Nations (UN) has proposed and promoted a framework for corporate environmental, social, and governance (ESG) performance, which requires micro-entities to integrate these aspects into their economic decision-making processes.

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Data reveal that in 2020, the total investment scale of major developed countries amounted to 98.33 trillion USD, with ESG investment accounting for a substantial 35.9%. While China's ESG development started later and has a lower market penetration compared to European and American markets, it has experienced rapid overall growth. Companies in China are increasingly strengthening their ESG investment, and more investors are incorporating ESG concepts into their decision-making processes, which is having a growing impact on enterprise development.

Environmental protection in China has also been reinforced, with compulsory policies driving the implementation of environmental regulations. In September 2018, the US Securities and Exchange Commission (SEC) added environmental protection and social responsibility to the Code of Governance of Listed Companies, establishing a foundational framework for ESG disclosure. Similarly, in September 2020, the Shenzhen Stock Exchange (SZSE) revised the Measures for Assessment of Information Disclosure of Listed Companies, incorporating an assessment of ESG disclosure behavior for the first time. The SEC also mandated full disclosure of environmental information in prospectuses.

Given the impact of the coronavirus disease 2019 (COVID-19) pandemic and the significant uncertainty in the global economy, ESG performance can help enterprises enhance their resilience to risks and promote high-quality development while increasing their social value. Therefore, theoretical research that is tailored to local conditions is urgently needed [1].

Financing plays a critical role in an enterprise's development life cycle, and corporate ESG performance can significantly influence corporate financing behavior, especially in the context of green finance, where commercial banks are actively developing green credit. The operating activities and cash positions of enterprises are affected by mandatory and market-based environmental regulations, which in turn impact the cost of debt financing. However, there is no consensus on the exact impact of ESG performance. On the one hand, good ESG performance can help mitigate agency problems and reduce legal risks associated with environmental issues, thereby alleviating corporate financing constraints [2]. On the other hand, due to the lack of unified ESG information rating standards, managers may engage in rent-seeking behavior, which can increase costs and harm shareholders' interests, negatively affecting enterprises [3]. Current research suggests that factors such as digital transformation, green credit, and internal controls significantly influence the cost of enterprise debt financing. The rise in debt financing costs can impact innovation performance, investment efficiency, and overall corporate performance. However, the existing ESG performance framework often overlooks the impact of debt financing costs. Therefore, studying the relationship between ESG performance and debt financing costs is crucial

and can provide empirical evidence to promote active engagement in ESG practices and foster sustainable development.

This study empirically investigates the impact of ESG performance on debt financing costs for heavy-polluting enterprises, focusing on three dimensions: corporate environment, social responsibility, and corporate governance. Using data from Chinese A-share listed heavy-polluting industries spanning from 2010 to 2020, this study examines the moderating effect of corporate green innovation through a moderating mechanism analysis, and analyzes the heterogeneity based on corporate nature, corporate domicile, and audit opinion. The findings indicate that the ESG performance of an enterprise can lead to a reduction in its debt financing costs. Furthermore, engaging in green innovation practices strengthens this effect. From the standpoint of reputation, green innovation behavior can contribute to a positive reputation [4]. Additionally, from the perspective of resource utilization, green innovation behavior can attract key stakeholders [5] and reduce the cost of corporate debt financing.

The potential contributions of this paper are as follows. First, the paper reveals the relationship between enterprise ESG practices and debt financing costs, enriches the relevant research on enterprise financing constraints, and broadens the research framework for the influencing factors of debt financing costs. Moreover, it clarifies the mitigation of enterprise financing constraints and the formulation of ESG strategy. Second, this paper introduces enterprise green technology innovation as a regulatory variable, and analysis of the mechanism provides new theoretical support for reducing financing costs through green technology innovation. Third, the heterogeneous analysis of region, enterprise nature, and audit opinions revealed the different effects of these factors on the relationship between ESG and financing costs. This finding provides not only guidance for developing more refined ESG management and financing strategies, but also a deeper understanding of the regional differences in financial markets and the heterogeneity of corporate properties under the influence of ESG.

Literature Review and Research Hypothesis

Studies Related to ESG Performance

The ESG framework, introduced by the UN in June 2004, aims to assess the sustainability of enterprises. The discussion surrounding corporate social responsibility (CSR) theory dates back to the 1930s when the negative externalities of economic activities prompted the question of 'to whom should companies be accountable?' This led to the division of CSR theory into two schools of thought: shareholderism and stakeholderism [6]. Shareholderism, also known as shareholder supremacism, focuses primarily

on the interests of enterprises and aligns with traditional liberal economic theory, which can exacerbate income inequality in developed countries. Stakeholderism, pursues the overall interests of the stakeholders, not just the interests of some subjects. However, the emergence of sustainable development theory bridged the gap between traditional liberal economic theory and CSR theory, providing a foundation for the development and widespread adoption of the ESG framework.

With the establishment of China's dual-carbon goal, the ESG concept has gained solid support at the policy level. In 2016, the People's Bank of China and seven other ministries and commissions jointly issued the Guidelines on Building a Green Financial System, which has helped China to establish a more environmentally friendly and sustainable financial framework in various sectors [7]. Subsequently, the Securities Regulatory Commission (CSRC) revised the Governance Guidelines for Listed Companies in 2018 [8] to emphasize the guiding role of listed companies in environmental protection and social responsibility, and provide the basic framework for ESG information disclosure in China. To further promote the concept of ESG, the Asset Management Association of China also released the Research Report on ESG Evaluation System of Chinese Listed Companies [9]. This report proposes a comprehensive ESG performance rating system for listed companies, further promoting the importance of ESG in business operations. In 2020, the State Council [10] issued the Guiding Opinions on Building a Modern Environmental Governance System, which clearly outlined the requirements for establishing and improving the enterprise environmental governance responsibility system, and emphasized the importance of disclosing environmental governance information. The release of these policy documents demonstrates China's progress in ESG at various levels, laying a solid foundation for promoting sustainable development and establishing a green financial system.

Enterprises must consume a large amount of capital to fulfill their ESG responsibilities. However, the development of green finance and implementation of green credit policies have greatly increased enterprise financing constraints, and ESG performance has become an important reference factor for enterprise stakeholder investment. Since the green credit policy was implemented, the public media have paid more attention to the environmental pollution generated by enterprises. The environmental pollution caused by enterprises can lead to major public opinion risks and even litigation risks, which will affect creditors' judgment and raise the financing threshold [11] (Li Xingong and Zhu Yanping, 2021). By implementing punitive high interest rates, banks can reduce the output of highly polluting enterprises in the short and medium term, thus curbing the level of debt investment and financing [12] (Ding Jie, 2019). For heavy-polluting industries, transforming clean energy is imperative, and to reduce emissions, green emission reduction technologies should be introduced or innovated, thereby reducing green credit costs

and easing financing constraints [13] (Liu Chuanjiang et al. 2022). In addition, some scholars believe that corporate social responsibility is part of management strategy, which reduces shareholder resource allocation, weakens enterprise competitiveness, increases the risks in enterprise development, and even damages enterprise value [14] (Surroca, 2008). Especially in private enterprises, higher ESG performance reduces enterprise value performance [15] (Cui, 2015). Therefore, the risk increase hypothesis holds that ESG practices will bring high financial and operational risks to the enterprise. In considering the overall operational risks of the enterprise, the management may be forced to forfeit certain investment opportunities to improve the enterprise ESG performance, or make only the most favorable decisions for the enterprise within the limited scope of environmental behavior.

However, there is an opposing view to the risk reduction hypothesis. Specifically, enterprise ESG has a positive impact on enterprise innovation, by stabilizing customer relations and reducing financial risks. First, ESG practices help enterprises obtain innovation resources from stakeholders and, thus, improve their innovation capabilities [16] (Li Jinglin et al., 2021). Second, enterprises can enhance product differentiation and information transparency through ESG practices, thereby enhancing enterprise competitiveness and customer relationship stability [17] (Chen Jiaojiao et al., 2023). Moreover, the value effect of ESG performance lags behind and may not be reflected in the short term. In countries with imperfect market systems, the ESG value is significantly positively correlated with corporate profitability and value [18, 19] (Ghoul et al., 2017), (Brogi et al., 2019). Good ESG performance will enable the enterprise to obtain a higher price-to-book ratio and price-earnings ratio [20] (Shi Yichen et al., 2021), and corporate adherence to ESG practices is also conducive to sustainable development [21] (Yi Lingxue et al., 2022).

Studies Related to the Cost of Debt Financing

Enterprise financing channels can be categorized into two types: debt financing and equity financing. In this discussion, we will focus on debt financing. Debt financing offers several advantages, including fast access to funds, lower costs, and fewer restrictive conditions, among others [22]. The cost of debt financing is influenced by various factors, including the macro environment and company characteristics [23]. The macro environment affects creditors' evaluations of business risk and can be characterized by interest rate marketization and policy uncertainty.

Regarding the relationship between interest rate liberalization and debt financing cost, many scholars have focused on the information asymmetry between enterprises and stakeholders. As an important subject of social production and environmental consumption, the importance of corporate environmental behavior

is self-evident [24] (Lv Minghan et al., 2018). However, corporate environmental responsibility and economic interests are relative, and stakeholders attach great importance to the sustainable development capabilities of enterprises, thus, enterprises need to disclose environmental information [25] (Li Huiyun et al., 2022). As China has not formally established a mandatory environmental disclosure system, considerable differences exist in the environmental disclosures of A-share listed companies, and the disclosure situation is relatively singular [26] (Shen Hongbo et al., 2022). The information asymmetry between enterprises and stakeholders increases the cost of identifying creditors [27] (Zhou Yan and Chen Hu, 2022), leading to a higher risk for creditors in making credit decisions [28] (Zhang Jiaoning et al., 2021). Therefore, creditors have introduced a differentiated pricing mechanism (Ye Li and Fang Ying, 2020) [29]. With the promotion of interest rate liberalization, banks' credit risk pricing ability will improve [30] (Li Hongjin, 2015). Moreover, through the price and competition mechanism, banks will be encouraged to expand high-quality customers [31] (Zhao Ping and Yao Yaojun, 2022), and improve the interest rate pricing for enterprises with high environmental pollution [32] (Liu, 2019).

The relationship between environmental regulation and debt financing costs can be summarized as the enhancement of financing constraints and the mitigation of financing constraints. Based on the legitimacy theory, enterprise managers make decisions according to the external institutional environment and the belief system of the public [33] (Chen Hua et al., 2013). The government's environmental regulations exert external pressure on enterprises and place mandatory constraints on their environmental behavior [34] (Hu Zongyi et al., 2022). The reason for the constraints is the green credit policy implementation, which leads to the financing problems of high polluting enterprises [35, 36] (Shi Yongdong et al., 2022, Ma Yahong, 2021). On January 1, 2015, the implementation of the new Environmental Protection Law increased the environmental risks faced by heavy-polluting industries. The funding obtained from financial institutions decreased and financial liabilities significantly decreased, while operating liabilities significantly increased [36]. When information is asymmetric, creditors demand a higher return on investment for enterprises with environmental risks. However, when corporate ESG performs well, investor confidence increases and investors can accept lower investment returns [37] (Li Hongwei and Huang Guoliang, 2015). On the contrary, according to the theory of signal transmission, enterprises convey information such as their fulfillment of social responsibilities and implementation of environmental protection, which can reduce their own credit risks and produce the mitigation effect of financing constraints [38] (Wu Hongjun, 2017).

Corporate governance level, profitability, information disclosure quality, executive background,

and other characteristics also affect corporate debt financing costs. Enterprise internal control plays a risk control role in enterprise debt financing decisions, and improving the internal control level is conducive to improving financing efficiency [39] (Lin Zhonggao and Ding Maohuan, 2017). When enterprises disclose environmental information, a more attractive report indicates a greater ability to convey positive information, reduce the creditors' assessment of risks, and enlarge the positive impact of the report on debt financing [40] (Ma Baojun et al., 2022). Specific to the characteristics of participants in corporate decision-making, the background and behavior of executives also affect debt financing costs. Senior executives are responsible for resource acquisition, reputation management, and information transmission, and those with a financial background or who work in the industry can help enterprises reduce debt financing costs [41, 42] (Qi Zipeng and Zhou Yunchen 2021, Diao Shuntao 2022). At the same time, senior executive turnover increases the financial risk of the enterprise, thus significantly increasing its debt financing costs [43] (Huang Rong et al., 2022).

Literature Review

In the context of green finance development, the environmental behavior of enterprises is crucial as they need to consider environmental responsibility while ensuring economic benefits. Financial institutions, especially banks, have integrated corporate environmental risks into credit management practices. Faced with pressure from the government, banks, and society, ESG performance has become an important metric to assess the fulfillment of corporate environmental responsibility. Existing studies have explored factors influencing the cost of corporate debt financing at the macro and micro levels, as well as the economic consequences of corporate ESG performance. However, few studies have specifically examined the relationship between ESG and the cost of corporate debt, and none have focused on the impact of ESG performance on debt financing costs for heavy-polluting firms. Considering the current state of green finance development in China, this study aims to investigate whether ESG performance influences the cost of corporate debt financing and explore the mechanisms underlying this influence. The findings of this study can provide insights for optimizing the green behavior of enterprises and reducing the cost of debt financing.

Hypothesis Formulation

Enterprise development relies on external financing support, primarily through debt financing. Creditors assess a company's operating risks to determine the cost of debt financing [44]. ESG performance emphasizes meeting stakeholder demands, pursuing sustainable development, and creating both economic and social

value [45]. Therefore, for creditors who receive fixed principal and interest, the ESG performance of a company naturally becomes a focal point of their attention [46]. From the perspectives of operating risk, additional income, and alleviation of information asymmetry, this paper analyzes the role path of ESG performance on corporate debt financing costs.

From a business risk perspective, stable operations are crucial in ensuring timely debt repayment by a company. Enhanced ESG performance, coupled with improved human capital and management capabilities, can help companies accumulate ethical and reputational capital and mitigate losses from negative events [47]. As ESG-related regulations strengthen, a decline in corporate ESG performance, incidental legal actions, and administrative regulations can result in economic losses and reputation damage [48], leading to operational instability and reduced confidence in future solvency [49, 50]. If a company experiences strained or interrupted cash flow due to performance fluctuations, creditors may face the risk of debt restructuring or even complete loss of their investment [43]. Consequently, creditors may demand higher risk premiums to safeguard their interests.

In addition to corporate business risk, corporate ESG performance can yield additional benefits and indirectly impact the investment risks faced by external creditors. When identifying investment portfolios that incorporate corporate ESG performance, traditional investment strategies typically consider firm size and value. However, including ESG performance in portfolios can have a significant synergistic effect on stock value [51], thereby enhancing investment returns [52].

Finally, based on the theory of information asymmetry, to avoid the agency cost caused by information asymmetry, enterprises need to make effective information disclosures to alleviate the agency cost between enterprises and creditors, thereby reducing the risk perception of creditors and the cost of debt financing [53]. ESG information is non-financial information, and its disclosure is an effective way to strengthen ESG practices. With the increase in ESG information disclosures, the fulfillment of corporate social responsibility can be conveyed to the outside world, and creditors can obtain more information from enterprises to alleviate information asymmetry [54]. At the same time, good quality ESG information disclosures can more effectively help creditors understand the enterprise, and thus initiate financing and reduce debt financing costs.

As a result, investors tend to prefer investing in companies with better ESG performance. Considering both the perspectives of business risk and information asymmetry, creditors also exhibit a preference for investing capital in enterprises with superior ESG performance [55]. Consequently, enterprises strive to improve their ESG performance, which facilitates attracting financial support, alleviating financing constraints, and reducing debt financing costs.

Therefore, the first research hypothesis is proposed as follows:

H1a: The better the ESG performance of heavy-polluting firms, the more likely the firms are to reduce their debt financing costs.

Heavy-polluting industries are characterized by high energy consumption and pollution, making them significant contributors to environmental pollution and carbon emissions in China [56]. Consequently, stricter environmental regulations have been implemented, posing substantial risks and challenges for heavy polluters. ESG practices in these industries often require significant upfront investments and have longer-term implementation periods [57]. Traditionally, investors in heavy-polluting industries may show less concern for the efforts made by these companies to improve their environmental performance. Their focus may be primarily on achieving high expected returns, potentially overlooking environmental risks and sacrificing the interests of other stakeholders. However, enterprises in heavy-polluting industries are influenced by mandatory environmental regulations and the concept of sustainable development. They invest considerable resources in research and development of green technologies, which can impact short-term earnings and influence investor decision-making. As a result, these companies may experience higher financing costs.

Thus, the following competing hypothesis is proposed in relation to H1b:

H1b: The better the ESG performance of heavy polluters, the more likely the firms are to increase their debt financing costs.

Experimental Procedures

Sample and Data

This study aims to examine the impact of corporate ESG performance on corporate debt financing costs. The analysis focuses on listed companies operating in the heavy-polluting industries in Shanghai and Shenzhen from 2010 to 2020 as the analysis sample. Financial data for this study were sourced from the China Stock Market and Accounting Research and China Research Data Services (CNRDS) databases, while ESG performance data were obtained from the Wind database. The sample selection process followed two principles: (1) excluding Special Treatment (ST) samples and retaining normal operation samples, and (2) winsorizing the main continuous variables by 1% up and down to avoid the influence of extreme values.

Model Design

To test the impact of corporate ESG performance on the cost of debt financing, we developed a model:

$$Cost_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \sum \alpha_k Control_{i,t} + \gamma + \mu + \varepsilon_{i,t}$$

where Cost is the corporate debt financing cost variable, ESG represents corporate ESG performance, control represents the set of control variables, γ represents individual fixed effects, μ represents time fixed effects, and ε is the random error term. The model controls for industry and annual fixed effects. Meanwhile, cluster treatment is performed at the firm level to mitigate the effects of serial autocorrelation. The article mainly focuses on the coefficient of α_1 .

To investigate the mechanism through which corporate ESG performance affects the cost of corporate debt financing, we introduce Model (2) as follows:

$$Cost_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \alpha_2 M_{i,t} + \alpha_3 ESG_{i,t} \times M_{i,t} + \sum \alpha_k Control_{i,t} + \gamma + \mu + \varepsilon_{i,t}$$

This study focuses on the moderating effect of corporate green innovation to investigate the mechanism of ESG performance on the cost of corporate debt financing. The variable M represents the mechanism variable, which specifically examines the intensity of corporate green innovation. The coefficient of the cross-product term, α_3 , in the regression equation is examined. A positive coefficient indicates that this mechanism promotes the impact of ESG performance on the cost of corporate debt financing, whereas a negative coefficient suggests an inhibiting effect.

Variable Definition

Explained Variables

In this study, corporate performance (ESG) is measured using data from Xie and Lv [46] and Lin et al. [58], as well as data from the China Securities Index (CSI) ESG rating system. The CSI ESG rating system categorizes companies into nine grades based on their ESG performance. The evaluation results for each quarter of the year are averaged, and scores ranging from 1 to 9 are assigned, with higher scores indicating better ESG performance.

Explanatory Variables

In relation to the cost of corporate debt financing (Cost), this study refers to the methodology used by Li

and Liu [59] and Wei et al. [60]. The metric employed is the proportion of corporate finance costs to total liabilities at the end of the period. This measure helps identify the portion of finance costs that are incurred within the finance cost account on the balance sheet.

Control Variables

Referring to Wang et al. [47] and Muyuan and Hong [61], as well as considering the specific findings of this study, several control variables are incorporated. These control variables include enterprise size, gearing ratio, net profit ratio of total assets, cash flow ratio, fixed assets ratio, operating income growth rate, ratio of independent directors, presence of dual positions, shareholding ratio of top 10 shareholders, Tobin's Q value, and the nature of enterprise ownership. The inclusion of these control variables aims to account for their potential influence on the model. The control variables are presented in Table 1.

Results and Discussion

Descriptive Statistics and Correlation Analysis

Table 2 presents the descriptive statistics results for the main variables. The findings reveal that the average debt financing cost (cost) for the sample companies is 1.522%, with significant variation observed among different companies. In terms of ESG performance (ESG), the findings demonstrate wide variation among heavy-polluting companies, with an overall poor performance. Table 3 displays the results of the Pearson correlation test. The absolute values of the correlation coefficients between most variables are below 0.4, indicating a lack of severe collinearity between the variables. Furthermore, the initial verification confirms a strong negative correlation between the explanatory variables and the explained variables.

Baseline Regression Results

Table 4 presents the results of the analysis on the effect of corporate ESG performance on the cost of debt financing. The findings indicate a significant negative

Table 1. Definition of main variables.

	Variable name	Variable symbol	Variable description
Explained variable	Cost of debt financing	Cost	Finance costs/total liabilities at end-of-period
Explanatory variable	Corporate ESG performance	ESG	China Securities ESG Index
Mechanism variable	Green innovation	Green	The sum of the annual number of green patents plus one, which is taken as the natural logarithm

Table 1. Continued.

Control variables	Enterprise size	<i>Size</i>	Natural logarithm of total assets for the year
	Gearing ratio	<i>Lev</i>	Total liabilities at the end of the year divided by total assets at the end of the year
	Net profit margin on total assets	<i>Roa</i>	Net income / Average balance of total assets
	Total assets turnover ratio	<i>Ato</i>	Operating income / Average total assets
	Cash flow ratio	<i>Cashflow</i>	Net cash flow from operating activities divided by total assets
	Percentage of accounts receivable	<i>Rec</i>	Ratio of net accounts receivable to total assets
	Inventory as a percentage	<i>Inv</i>	Net inventory to total assets ratio
	Percentage of fixed assets	<i>Fixed</i>	Net fixed assets to total assets ratio
	Operating income growth rate	<i>Growth</i>	Operating income for the year / Operating income for the previous year - 1
	Whether there is loss	<i>Loss</i>	Net profit for the year less than 0 is taken as 1, otherwise it is taken as 0
	Percentage of independent directors	<i>Indep</i>	Independent directors divided by the number of directors
	Two jobs in one	<i>Dual</i>	The chairman and general manager, being the same, is assigned a value of 1, otherwise 0
	Shareholding ratio of major shareholders	<i>Top1</i>	Number of shares held by the largest shareholder / Total number of shares
	Tobin's Q value	<i>Tobinq</i>	(Market value of outstanding shares + number of non-marketable shares × net assets per share + book value of liabilities) / Total assets
	Nature of ownership	<i>Soe</i>	Judgement according to the actual controller; state-owned enterprises take a value of 1, and the others 0.

Table 2. Descriptive statistics of the main variables.

Variable	Sample size	Average value	Median	Standard deviation	Minimum value	Maximum value
<i>Cost</i>	8533	1.522	2.055	3.137	-16.15	7.069
<i>ESG</i>	8429	4.125	4	1.045	1	7.250
<i>Size</i>	8542	22.29	22.08	1.334	19.52	26.40
<i>Lev</i>	8542	0.432	0.425	0.206	0.0270	0.925
<i>Roa</i>	8542	0.0410	0.0380	0.0630	-0.398	0.244
<i>Ato</i>	8542	0.692	0.612	0.423	0.0530	2.907
<i>Cashflow</i>	8542	0.0540	0.0540	0.0690	-0.224	0.257
<i>Rec</i>	8512	0.0910	0.0670	0.0850	0	0.507
<i>Inv</i>	8523	0.133	0.105	0.118	0	0.772
<i>Fixed</i>	8542	0.290	0.269	0.172	0.00200	0.736
<i>Growth</i>	8539	0.155	0.0880	0.408	-0.660	4.330
<i>Loss</i>	8542	0.105	0	0.306	0	1
<i>Indep</i>	8533	0.372	0.333	0.0520	0.273	0.600
<i>Dual</i>	8542	0.242	0	0.429	0	1
<i>Top1</i>	8533	0.362	0.340	0.151	0.0830	0.758
<i>Tobinq</i>	8393	1.867	1.480	1.256	0.802	17.73
<i>Soe</i>	8542	0.404	0	0.491	0	1

Table 3. Correlation matrix of main variables.

Variable	<i>Cost</i>	<i>ESG</i>	<i>Size</i>	<i>Lev</i>	<i>Roa</i>	<i>Ato</i>	<i>Cashflow</i>
<i>Cost</i>	1						
<i>ESG</i>	-0.121***	1					
<i>Size</i>	0.222***	0.203***	1				
<i>Lev</i>	0.503***	-0.126***	0.500***	1			
<i>Roa</i>	-0.273***	0.235***	-0.037***	-0.426***	1		
<i>Ato</i>	0.0110	0	-0.057***	-0.020*	0.187***	1	
<i>Cashflow</i>	-0.045***	0.093***	0.127***	-0.114***	0.374***	0.119***	1
<i>Rec</i>	0.0110	-0.066***	-0.298***	-0.104***	0.00700	0.114***	-0.189***
<i>Inv</i>	0.0140	0.018*	-0.0170	0.132***	-0.041***	0.108***	-0.214***
<i>Fixed</i>	0.323***	0.00800	0.283***	0.301***	-0.160***	-0.0110	0.225***
<i>Growth</i>	-0.00100	-0.0170	0.024**	0.018*	0.232***	0.126***	0.0170
<i>Loss</i>	0.146***	-0.187***	-0.038***	0.242***	-0.628***	-0.108***	-0.181***
<i>Indep</i>	-0.0150	0.061***	-0.0160	-0.0120	-0.0130	-0.0130	0.00100
<i>Dual</i>	-0.079***	-0.00400	-0.187***	-0.143***	0.054***	-0.019*	-0.043***
<i>Top1</i>	-0.038***	0.128***	0.286***	0.067***	0.109***	0.087***	0.094***
<i>Tobinq</i>	-0.147***	-0.164***	-0.392***	-0.195***	0.117***	0.00500	0.063***
<i>Soe</i>	0.125***	0.073***	0.399***	0.345***	-0.139***	0.0120	0.045***
Variables	<i>Rec</i>	<i>Inv</i>	<i>Fixed</i>	<i>Growth</i>	<i>Loss</i>	<i>Indep</i>	<i>Dual</i>
<i>Rec</i>	1						
<i>Inv</i>	-0.032***	1					
<i>Fixed</i>	-0.319***	-0.350***	1				
<i>Growth</i>	0.057***	0.0120	-0.065***	1			
<i>Loss</i>	-0.032***	-0.0100	0.100***	-0.180***	1		
<i>Indep</i>	0.032***	-0.0130	-0.062***	0.00400	0.0130	1	
<i>Dual</i>	0.123***	0.020*	-0.155***	0.025**	-0.026**	0.092***	1
<i>Top1</i>	-0.122***	0.0160	0.088***	0.018*	-0.066***	0.0170	-0.049***
<i>Tobinq</i>	0.046***	0	-0.161***	0.025**	0.038***	0.067***	0.033***
<i>Soe</i>	-0.268***	-0.086***	0.350***	-0.048***	0.068***	-0.027**	-0.297***
Variables	<i>Top1</i>	<i>Tobinq</i>	<i>Soe</i>				
<i>Top1</i>	1						
<i>Tobinq</i>	-0.145***	1					
<i>Soe</i>	0.235***	-0.110***	1				

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

effect at the 1% level. Upon gradually introducing control variables, the coefficient remains negative and significant at the 5% level. These results in Table 4 validate hypothesis H1a, thus confirming that hypothesis H1b is not supported.

Robustness Tests

Substitution of Explanatory Variables

This study adopts the approach of Li and Liu [59] and Wei et al. [60] to measure the corporate debt financing cost. Specifically, the measure is revised as (interest

Table 4. Impact of corporate ESG performance on the cost of debt financing.

Variable	Cost		
	(1)	(2)	(3)
ESG	-0.265***	-0.096**	-0.111**
	(0.054)	(0.044)	(0.045)
Lev		6.129***	5.703***
		(0.423)	(0.444)
Roa		-1.870**	-2.091**
		(0.835)	(0.858)
Ato		0.837***	0.988***
		(0.183)	(0.199)
Cashflow		1.738***	1.778***
		(0.554)	(0.556)
Rec		4.080***	4.128***
		(0.979)	(0.980)
Inv		1.891***	2.399***
		(0.694)	(0.740)
Fixed		5.884***	6.158***
		(0.489)	(0.498)
Growth		-0.042	-0.084
		(0.063)	(0.065)
Loss		-0.053	-0.034
		(0.104)	(0.106)
Size			0.315**
			(0.124)
Board			-1.032***
			(0.384)
Indep			0.122
			(1.015)
Dual			-0.146
			(0.122)
Top1			-1.413**
			(0.569)
Tobinq			-0.057
			(0.045)
Soe			-0.020
			(0.265)
_Cons	2.613***	-3.687***	-7.885***
	(0.223)	(0.388)	(2.954)
Year	YES	YES	YES
Stkcd	YES	YES	YES
N	8348.000	8298.000	8151.000
Adj R-squared	0.467	0.556	0.559

Note:***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively; t-values are in parentheses; standard errors are robust standard errors for firm-level clustering; Year represents time effects; and Stkcd represents individual effects.

expense + fee expense + other financial expenses)/end-of-period total debt (Cost2). The results show that the better the ESG performance of the firm, the lower the debt financing cost, which is demonstrated in Column 2 of Table 5, indicating that the regression results remain robust.

Excluding the Effects of Extreme Events

To mitigate the potential impact of the COVID-19 pandemic on firms' cash holdings, the 2020 sample was excluded from the analysis. This exclusion aims to eliminate the influence of extreme events on the regression results. The regression results, presented in Column 3 of Table 5, confirm the robustness of the findings.

Endogeneity Test

Lagged Variables

In order to address potential endogeneity issues, considering that the previous period of the endogenous variable is not correlated with the current period error term, a one-period lag of the endogenous variable was used instead of the current period endogenous variable. By incorporating both explanatory and control variables with a one-period lag, the estimation bias caused by endogeneity was mitigated. The results, as presented in Table 6, reveal that the estimated coefficients of the key variable (L.ESG) remain consistent with the previous findings. This indicates that the regression results remain robust, and the endogeneity problem has been alleviated.

Mechanism Test

Among the various indicators of corporate ESG performance, the focus on green behavior, particularly green innovation behavior, is of utmost importance. Green innovation represents the integration of economic and environmental benefits. This part will discuss whether enterprise green innovation can affect the relationship between enterprise ESG performance and debt financing costs, and whether the impact is positive or negative.

With the implementation of the national green innovation strategy, the green technology innovation of enterprises has been widely scrutinized in the investment market [62] (Yu Wei and Guo Xiaoyi, 2023), and may affect the market competitiveness of enterprises. When creditors realize the importance of green technology innovation, they tend to invest in enterprises that exhibit better performance in green technology innovation, thereby promoting enterprises to focus on environmental and sustainable development and improve ESG performance. However, as the green technology innovation of enterprises requires a large amount of R&D funding, and uncertainty often exists

Table 5. Robustness tests.

Variable	Cost2	Cost
	(1)	(2)
<i>ESG</i>	-0.080*** (0.024)	-0.097** (0.048)
<i>Constant</i>	-0.991 (1.628)	-0.248 (1.815)
<i>Control variables</i>	YES	YES
<i>Year</i>	YES	YES
<i>Stkcd</i>	YES	YES
<i>N</i>	8151.000	6525.000
<i>Adj R-squared</i>	0.610	0.607

Note:***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively; t-values are in parentheses; standard errors are robust standard errors for firm-level clustering; Year represents time effects; and Stkcd represents individual effects.

Table 6. Endogeneity test.

Variable	Cost
	(1)
<i>L.ESG</i>	-0.151*** (0.043)
<i>Constant</i>	-8.013*** (2.638)
<i>Control variables</i>	YES
<i>Year</i>	YES
<i>Stkcd</i>	YES
<i>N</i>	9660.000
<i>Adj R-squared</i>	0.547

Note:***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively; t-values are in parentheses; standard errors are robust standard errors for firm-level clustering; Year represents time effects; and Stkcd represents individual effects.

in innovation behavior, technological innovation may not necessarily be transformed into enterprise performance. For heavy polluting enterprises, green technology innovation requires the long-term capital invested by enterprises. The R&D expenditure of green innovation should be included in the current expenses according to the accrual basis principle. However, the transformation of R&D results has a lag, which will lead to a decline in short-term earnings. Therefore, cost-benefit conversion may cause creditors to invest cautiously, thus inhibiting corporate ESG performance.

Table 7. Mechanism of influence of corporate ESG performance on the cost of debt financing.

Variable	Cost
	(1)
<i>Green*ESG</i>	-0.000** (0.000)
<i>ESG</i>	-0.001* (0.000)
<i>Constant</i>	-0.078*** (0.030)
<i>Control variables</i>	YES
<i>Year</i>	YES
<i>Stkcd</i>	YES
<i>N</i>	8151
<i>Adj R-squared</i>	0.559

Note:***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively; t-values are in parentheses; standard errors are robust standard errors for firm-level clustering; Year represents time effects; and Stkcd represents individual effects.

In this study, we introduce the level of corporate green innovation as a moderating variable. To measure the extent of green innovation, we refer to the methodology employed by Yu et al. [63] and Rong and Luxi [64], utilizing the number of green patent applications from the CNRDS database. To capture corporate green innovation, the natural logarithm of the sum of a company's green patents in a given year, plus one, is computed (Green). As shown in Table 7, enterprise green innovation expands the influence of ESG on the debt financing cost of enterprises. In instances of higher intensity of enterprise green innovation, an increase in ESG ratings is observed alongside a decrease in the firm's debt financing cost.

Further Analysis

Heterogeneity of Business Nature

To verify whether the impact of ESG performance on corporate debt financing costs will be significantly different among enterprises with different property rights, this paper groups the sample enterprises and examines state-owned enterprises (SOEs) and private enterprises, respectively. The results are shown in columns 1 and 2 of Table 8. For SOEs, their ESG performance will have a certain reduction effect on their debt financing cost. However, this effect is not significant, probably because SOEs usually have a stronger financing advantage, which is their relative ease in obtaining low-cost financing channels compared

Table 8. Results of the heterogeneity test.

Variable	Nature of business		Region			Auditors' opinion	
	State-owned enterprises	Private enterprises	East	Middle	West	Standard comments	Non-standard opinions
	<i>Cost</i>	<i>Cost</i>	<i>Cost</i>	<i>Cost</i>	<i>Cost</i>	<i>Cost</i>	<i>Cost</i>
	(1)	(2)	(3)	(4)	(5)	(7)	(8)
<i>ESG</i>	-0.011	-0.118***	-0.001	-0.002**	-0.001	-0.110**	0.124
	(0.035)	(0.032)	(0.001)	(0.001)	(0.001)	(0.045)	(0.222)
<i>Constant</i>	3.672	-3.404	-0.081*	-0.032	-0.118**	-6.285**	-25.336**
	(2.497)	(2.278)	(0.044)	(0.056)	(0.050)	(2.965)	(11.806)
<i>Control variables</i>	YES	YES	YES	YES	YES	YES	YES
<i>Year</i>	YES	YES	YES	YES	YES	YES	YES
<i>Stkcd</i>	YES	YES	YES	YES	YES	YES	YES
<i>N</i>	3358	4770	5168	1588	1395	7902.000	155.000
<i>Adj R-squared</i>	0.681	0.585	0.537	0.612	0.630	0.565	0.518

Note:***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively; t-values are in parentheses; standard errors are robust standard errors for firm-level clustering; Year represents time effects; and Stkcd represents individual effects.

to private enterprises. In addition, SOEs are often subject to stricter constraints from government environmental regulations, thus, greater pressure is placed on ESG, but the impact may be relatively small due to their financing advantages. This result suggests that although SOEs may perform well in ESG, their impact on debt financing costs is relatively weak.

However, different trends are observed for private enterprises. Private companies seem more willing to take aggressive steps to improve their ESG performance. This includes promoting the implementation of environmental protection projects and optimizing environmental behavior. These efforts may be designed to meet the government's environmental goals, but they will also help reduce business risks in the environmental sector. As a result, these private companies are often able to obtain lower debt financing costs because investors are more willing to finance them, investors believe that the companies' ESG performance will help maintain future sustainable operations. This result highlights the importance of private initiatives in the ESG sector to reduce debt financing costs and improve competitiveness.

In conclusion, our results show that the ESG performance of state and private enterprises has different effects. These findings help to deepen our understanding of the role of ESG factors in corporate financing decisions, giving both companies and investors more insight into ESG management to optimize their financing strategies and sustainability performance.

Heterogeneity of Business Domiciles

The eastern region of China, known for its high level of economic development, places significant importance on the ESG performance of enterprises, with stricter government regulations in place [65]. This region usually has a higher level of industrialization and richer financial resources, enabling the government to more actively support and regulate the environmental, social, and governance performance of enterprises. At the same time, the degree of regional marketization is also relatively high in the eastern region, which helps to reduce the information asymmetry between investors and enterprises, improve the effective allocation of credit resources, and thus reduce the cost of debt financing. For the heavily polluting enterprises registered in the central and western regions, due to the regional economic development level and institutional environment factors, the ESG performance of the enterprises is not as good as that of the enterprises in economically developed regions, and the government lacks rich financial resources to provide funds, tax relief, and other policy support for the enterprises.

Therefore, this paper divides the whole sample into eastern, central, and western provinces according to the registered province, to examine the relationship between ESG and debt financing costs in different regions. The results show no significant relationship between ESG performance and debt financing costs in the eastern and western subgroups. By contrast, the central subgroup demonstrates a significantly negative association, indicating that better ESG performance in the central region is associated with lower debt

financing costs. By improving its ESG performance, the central region's debt financing costs can be reduced more effectively, thus generating greater competitiveness and more financing opportunities.

Heterogeneity of the Auditor's Opinion

The role of the auditor is crucial in bridging the gap between companies and external stakeholders, facilitating information exchange and communication channels, and enhancing the quality of corporate information disclosure through their professional expertise in corporate governance [5]. The auditor's expertise contributes to external governance and improves the quality of corporate disclosure. Auditors provide an opinion based on the uncertainty surrounding a company's operations, and creditors rely on the audit opinion to assess the company's solvency. Columns 7 and 8 of Table 8 demonstrate that when the auditor issues a standard opinion, this usually means that the company's business strategy is more compliant with ESG practices, and environmental violations are less likely. This shows that companies are more responsible and prudent in their operations, which helps creditors to wisely assess the solvency of companies. Therefore, it is easier for creditors to identify lower risk levels, thus reducing the debt financing costs of enterprises. This finding highlights the key role of auditors in corporate governance and ESG practices, and their importance to the debt market. However, when the auditor issues a non-standard opinion, the impact of corporate ESG performance on the debt financing costs is not significant. This may be because the non-standard opinions of auditors usually reflect the high uncertainty and risks involved in operating a business, in which creditors may focus more on the financial health of the business rather than its ESG performance. Thus, the auditor's opinion in this case may have a relatively small impact on the debt financing costs.

Conclusions

This empirical study investigates the influence mechanism of corporate ESG performance on debt financing costs using A-share listed companies in the heavy-polluting industries in China from 2010 to 2020. The findings reveal that good ESG performance can reduce the cost of corporate debt financing, with the impact further strengthened by green innovation behavior in heavy-polluting enterprises. The influence of ESG performance on debt financing costs is more evident for private heavy-polluting enterprises compared to SOEs. Additionally, better ESG performance in the central region of China reduces debt financing costs for heavy-polluting enterprises, while no significant effects are observed in the eastern and western regions. Furthermore, heavy polluters with standard audit opinions experience reduced debt

financing costs when exhibiting good ESG performance, while those issued with non-standard opinions show no significant effect.

This study provides several key insights. First, enterprises should prioritize their understanding of ESG performance, recognizing that their development should not come at the expense of the external environment. Microeconomic agents responsible for environmental governance should accept that responsibility and enhance their sense of social responsibility. Heavy polluters should leverage the reputation mechanism, strengthen green innovation, adopt cleaner production methods, and improve ESG information disclosure to mitigate information and default risks, earn creditors' trust, and reduce debt financing costs. Second, the government should enhance the ESG information disclosure system and implement relevant legislation. It should guide enterprises to disclose substantial ESG information, establish incentives and penalties based on their ESG performance, and conduct intra-industry evaluations specifically for heavy-polluting industries. Lastly, fostering the development of domestic ESG credit rating agencies that can offer professional ESG consultations to enterprises and stakeholders is crucial. These agencies should be industry-specific in their index creation and address the unique costs and behaviors required to improve ESG performance across different industries.

Conflict of Interest

The authors declare no conflict of interest.

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