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CORPORATE ENVIRONMENTAL DISCLOSURE, CORPORATE GOVERNANCE, AND COST OF DEBT IN CHINA'S PHARMACEUTICAL INDUSTRY

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Abstract:

In China, one of the largest emerging markets, the growing public demand for sustainable development has led creditors to place greater emphasis on corporate environmental performance. This study uses a sample of 1141 firm-year observations of Chinese listed pharmaceutical companies from 2018 to 2022, to empirically examine the impact of corporate environmental disclosure (ED) on the cost of debt (COD), as well as the moderating effect of corporate governance on this relationship. By employing a Fixed Effects regression model, the results show that enhanced ED significantly reduces the COD. Furthermore, corporate governance plays a significant positive moderating role in this process. Similar results are obtained using the two-step system Generalized Method of Moments (GMM) estimation, which can address the potential endogeneity issues. These findings provide valuable insights for Chinese pharmaceutical companies on how enhancing ED and governance can help lower financing costs, leading to a better balance between profitability and environmental protection. Specifically, such improvements are likely to result in more favorable financing conditions, benefiting companies, creditors, and the public in an evolving market. This paper also offers practical recommendations for corporate managers, creditors, and policymakers, aiming to enhance environmental disclosure standards, integrate such disclosures into financial risk assessment frameworks, and strengthen the effectiveness of corporate governance.

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Keywords:

ED, Financing Cost, COD, Emergency Market, Corporate Governance, Chinese Pharmaceutical Companies

Introduction

In the context of rapid economic transformation in emerging markets such as China, the accumulation of ecological and environmental issues has become increasingly prominent. As microeconomic entities drive social and economic development, enterprises also play a vital part in reconciling economic growth with environmental sustainability (Kan & Li, 2025). ED is an important channel through which various stakeholders- including the public, government, and creditors- obtain information regarding an enterprise's actual performance in fulfilling its environmental responsibilities. However, some enterprises still adopt a conservative attitude toward such disclosure, responding passively to disclosure requirements. This tendency stems from the inherent profit-seeking nature of enterprises, as they prioritize weighing costs and benefits in their business operations and decision-making (Wang, 2022). Suppose enterprises fail to fully and correctly recognize the economic benefits associated with ED. In that case, they may one-sidedly perceive it as a cost-increasing activity and thus avoid engaging in enhanced disclosure. Therefore, clarifying the impact of ED on financing costs can provide enterprises with intrinsic incentives to voluntarily improve disclosure practices and offer decision-making support for various stakeholders, including creditors.

In China, debt financing accounts for more than half of total external financing for most enterprises, with some companies relying on it for as much as 80% to 90% of their total funding (Fan, Fang, & He, 2017), which indicates that debt financing has become a crucial funding method for Chinese listed companies, particularly in light of *"The Guiding Opinions on Building a Green Financial System"* (The People's Bank of China et al., 2016), where strict lending requirements may impose greater debt financing pressures on heavily polluting industries (Liao, Jiang, & Wang, 2022). Notably, as one of the heavily polluting sectors, the pharmaceutical industry exhibits a strong demand for financing (Chinese Society of Biotechnology & Firestone-link, 2022). The Chinese pharmaceutical industry is subject to various healthcare reform policies—such as drug price negotiations and volume-based procurement—that have reduced profit margins and increased the industry's reliance on external financing (Liu, 2020). Additionally, pharmaceutical enterprises are both technology- and capital-intensive, requiring substantial financial investment over long development cycles and facing considerable risks and slow returns. These characteristics contribute to their relatively high COD (Shan & Qiu, 2021). Against this backdrop of high financing demand and elevated financing costs, clarifying the impact of ED on the COD for Chinese listed pharmaceutical companies can encourage better disclosure practices. Furthermore, it can enhance corporate accountability for environmental protection and support the broader goal of promoting green development.

However, due to the lack of detailed and standardized guidelines, as well as third-party audits and certifications, the credibility of ED by Chinese enterprises remains controversial (Cao & Xu, 2019). As a result, some studies have suggested that ED does not necessarily reduce the

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COD (Yao & Pan, 2018; Li, Chai, Zhang, & Zhang, 2022). Therefore, from an internal corporate perspective, such as corporate governance, enhancing the credibility of disclosed information has become a critical research focus for reducing financing costs.

Overall, in recent years, research on the impact of ED on the COD in China, an emerging market, has largely overlooked the pharmaceutical industry, a distinctive sector characterized by heavy polluting attributes and high financing demands. At the same time, existing studies present limitations regarding how corporate governance can further strengthen the impact. Accordingly, it remains necessary to examine whether ED by listed pharmaceutical companies in China can reduce the COD and whether corporate governance can further strengthen this negative relationship. Addressing these questions can give Chinese companies more substantial internal incentives and governance mechanisms, thereby contributing to practical outcomes such as encouraging more enterprises in emerging markets to improve their disclosure practices and increase investments in environmental protection.

Given the preceding discussion, this study contributes in the following ways: (1) In response to the inconsistent findings in existing research regarding the impact of ED on the COD (Yao & Pan, 2018; Guo & Qin, 2022; Li et al., 2022), this study concentrates on the pharmaceutical industry, leveraging its unique characteristics to deliver a more nuanced and precise examination of the ED-COD relationship. It clarifies the beneficial economic consequences of ED for pharmaceutical companies in emerging markets. (2) The empirical results further reveal that corporate governance strengthens the negative association between ED and the COD, enriching the existing literature and extending the application of relevant theoretical frameworks. Additionally, the findings offer a clear and practical pathway for improving corporate environmental practices and mitigating financing difficulties faced by pharmaceutical firms in emerging markets through enhancing corporate governance mechanisms.

Literature Review, Theory and Hypotheses Development

Literature Review

ED and COD

In China, a representative emerging market, extensive research has examined the link between environmental disclosure (ED) and the cost of debt (COD), yet findings remain inconclusive.

On one hand, several studies argue that enhanced ED can reduce COD by mitigating information asymmetry and boosting lender confidence. For instance, Fonseka et al. (2019, 2020), Guan and Xiao (2019), Zhao and He (2021), Guo and Qin (2022), and Li et al. (2022) focused on environmentally sensitive industries such as energy, textiles, and chemicals, and found that firms with better ED practices tend to face lower debt costs. Some of these studies adopt signaling theory, suggesting that voluntary ED sends positive signals to creditors about firms' environmental risk management and long-term stability (Wang & Guo, 2019; Wang & Yang, 2020). Guo and Qin (2022) further argue that ED serves as a form of internal self-monitoring that enhances corporate reputation and reduces financing costs.

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On the other hand, other studies present a more skeptical view. Du et al. (2020) and Li et al. (2022) find that ED has no significant impact on COD, while Zhu and Cai (2017) and Yao and Pan (2018) suggest that ED may even increase financing costs. These studies emphasize limitations in China's disclosure regime, where the lack of standardized, enforceable disclosure criteria allows for selective reporting and greenwashing. In some cases, detailed ED may highlight operational risks, prompting lenders to raise interest rates.

Internationally, most studies support the risk-mitigating effect of ED on COD. For instance, Hamrouni et al. (2020) report that high-quality ED significantly reduces COD among French listed companies. Morrone et al. (2022) find similar results among U.S. energy firms, noting that ED helps stakeholders better assess firms' environmental risks. In emerging markets, Febrinalda and Hasnawati (2022) and Tarulli et al. (2023) find that ED enhances firm credibility, reduces perceived lender risk, and leads to more favorable debt terms.

Taken together, while the potential of ED to reduce COD is well-supported, inconsistencies—particularly within China—highlight the influence of industry-specific factors, disclosure credibility, and regulatory context. Notably, limited research has focused on China's pharmaceutical industry, a sector with high capital intensity and significant environmental implications. This study addresses that gap by examining the ED–COD relationship in this underexplored yet policy-relevant context.

Moderating Effects of Corporate Governance

Several Chinese studies have explored how corporate governance (CG) moderates the relationship between ED and COD. Shan (2018), using a corporate governance index constructed via Principal Component Analysis, finds that effective governance strengthens the negative ED–COD relationship in heavily polluting firms. This suggests that governance quality enhances the credibility and utility of environmental disclosures for creditors.

Other scholars focus on specific governance mechanisms. Zhao and He (2021), and Zhao, Qu, and Wang (2023) find that state ownership enhances the ED–COD relationship. They argue that state-owned enterprises (SOEs) benefit from political connections and face greater societal scrutiny, which reinforces the impact of ED on lender decision-making.

By contrast, Guo and Qin (2022) and Dai and Dong (2017) report that internal controls and Big Four audits do not significantly moderate the ED–COD link. A possible explanation is that ED in China remains largely qualitative and lacks financial specificity, limiting the effectiveness of both internal governance mechanisms and third-party assurance in influencing creditor evaluations.

International evidence on this moderating effect is sparse. One notable exception is Latvala (2022), who finds that in Nordic countries, female board representation enhances the negative relationship between ESG disclosure and COD. Female directors are often associated with stronger stakeholder oversight and greater ESG accountability, thereby increasing the credibility of disclosures and reducing financing costs.

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Despite some encouraging findings, research on how corporate governance structures influence the ED–COD relationship remains fragmented. In particular, there is a need to explore this mechanism within high-risk, capital-intensive sectors such as pharmaceuticals, where governance may play a crucial role in shaping how lenders interpret environmental signals.

Theory

Stakeholder theory suggests that companies must proactively address the concerns of individuals and groups who can influence or be affected by their objectives (Freeman, 1984). ED is one such response, aiming to protect stakeholder interests by enhancing the transparency of the company's environmental performance (Brown & Fraser, 2006). Creditors, as key stakeholders, are particularly concerned with ED as it informs them about potential risks, such as environmental liabilities, which directly affect their lending decisions (Zheng, 2010). Firms that prioritize environmental protection are perceived to be more reliable and ethical, making them more attractive to creditors (Choi, Kim & Kim, 2017).

Signaling theory addresses the issue of information asymmetry, where firms typically possess more information than creditors (Spence, 1978). To reduce this asymmetry, firms with strong environmental practices often voluntarily disclose ED to communicate their positive attributes, thereby signaling lower risk and building trust with creditors (Cao & Qiao, 2023). This improves the firm's reputation, lowers perceived risks, and can ultimately result in a lower COD.

Agency theory (Jensen & Meckling, 1976) deals with the conflict of interest between principals (shareholders) and agents (managers). Managers might manipulate disclosures to serve their personal interests, which may mislead creditors. To better address agency issues, corporate governance grounded in agency theory can encourage agents driven by personal interests to make decisions that prioritize the maximization of principals' interests (Denis & McConnell, 2003). In this context, corporate governance can also affect the ED-COD relationship by balancing stakeholder interests and strengthening oversight functions. Effective corporate governance can balance stakeholders' interests (Dang & Lu, 2012), enabling well-governed companies to prevent specific internal stakeholders from manipulating the timeliness and accuracy of disclosed information for short-term gain. Moreover, effective corporate governance enhances the internal oversight functions of both the board of directors and the supervisory board (Liu & Liu, 2001). Enhanced internal governance mechanisms are associated with a greater commitment to corporate social responsibility and more comprehensive ED, thereby mitigating the likelihood of strategic or selective reporting influenced by managerial or shareholder self-interest. Enhanced ED builds greater trust among stakeholders, such as creditors, who are more likely to reduce transaction costs—ultimately lowering the COD.

Although stakeholder theory, signaling theory, and agency theory offer different perspectives on corporate behavior, they complement each other in explaining the relationship between ED and COD. Stakeholder theory underscores the importance of addressing external pressures, signaling theory focuses on reputation management, and agency theory emphasizes governance mechanisms that align managerial actions with creditor interests. Together, these theories form a robust framework for understanding how corporate governance can strengthen the ED-COD relationship.

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Hypotheses Development

Based on stakeholder theory (Freeman, 1984) and signaling theory (Spence, 1978), ED serves as a crucial mechanism for reducing information asymmetry between firms and external stakeholders, particularly creditors. Enhanced ED improves transparency, mitigates environmental risk concerns, and enhances firms' reputations, thereby reducing creditors' required risk premiums and lowering the COD.

Empirical evidence from both emerging and developed markets supports this relationship. Studies have found that enhanced ED significantly reduces the COD by alleviating information asymmetry and enabling creditors to make better-informed lending decisions (e.g., Guan & Xiao, 2019; Hamrouni et al., 2020; Zhao & He, 2021; Febrinalda & Hasnawati, 2022; Guo & Qin, 2022; Tarulli et al., 2023). Based on the above discussion, the following hypothesis(H1) is proposed:

H1: Enhanced ED can reduce the COD.

However, the effectiveness of ED in reducing financing costs may depend on the credibility of the disclosed information, which is closely linked to the firm's corporate governance practices. According to agency theory (Jensen & Meckling, 1976), effective corporate governance mechanisms help align the interests of managers and stakeholders, enhancing the accuracy, timeliness, and comprehensiveness of disclosures. It can strengthen internal monitoring, discourage opportunistic behavior, and improve the reliability of information conveyed to external parties (Denis & McConnell, 2003; Li, 2014).

Furthermore, existing research suggests that corporate governance can moderate the ED-COD relationship. For instance, Shan (2018) demonstrated that overall corporate governance quality enhances the negative effect of ED on debt financing costs in Chinese firms. Similarly, Zhao and He (2021) emphasized the differential effects of ownership structure, a key corporate governance component variable, on this relationship. Considering corporate governance as an integrated mechanism (da Silva & Leal, 2005), a composite corporate governance index may better capture its moderating role in strengthening the signaling function of ED. Based on the above discussion, the following hypothesis (H2) is proposed:

H2: Corporate governance has a positive moderating effect on the impact of ED on the COD.

Theoretical Framework

Based on the theories and hypotheses discussed, this study presents a theoretical framework to visually illustrate the relationships between ED, COD, and Corporate Governance. Figure 1 below visually represents the framework, incorporating the hypotheses that guide the empirical analysis.

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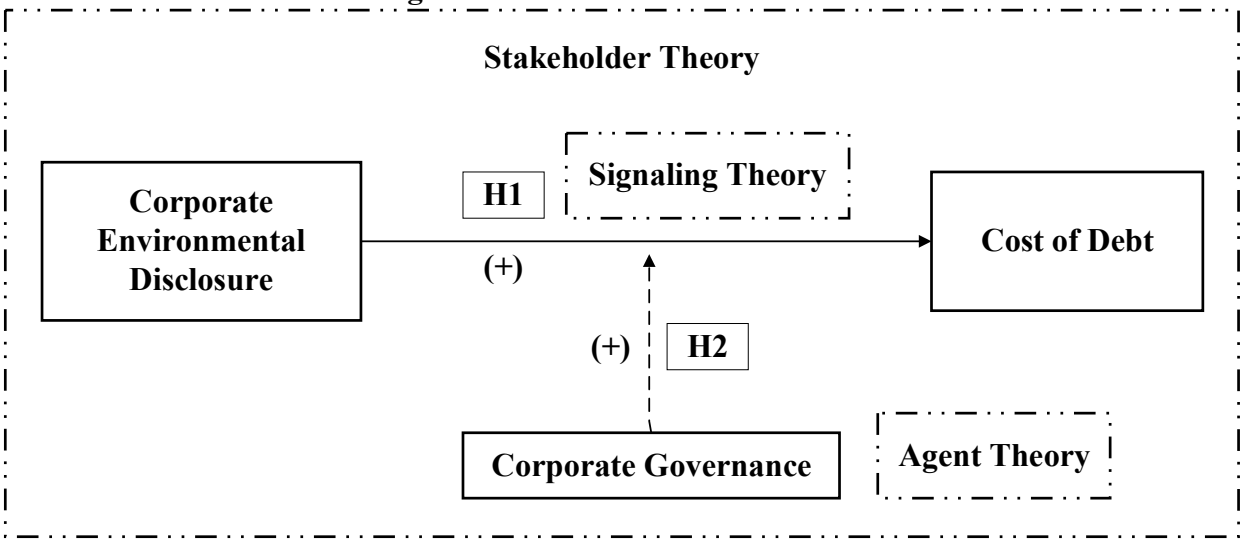
Figure 1 Theoretical Framework



Research Methodology

Sample and Data Considerations

This study selects A-share pharmaceutical listed companies on the Shanghai Stock Exchanges and Shenzhen Stock Exchanges in China from 2018 to 2022 as the initial research sample. To ensure data reliability, we applied the following screening criteria: first, we excluded pharmaceutical companies classified as ST or ST during the study period; second, we removed firms with incomplete financial disclosures. As a result, our final sample includes 313 listed pharmaceutical companies in China.

All data in this study are sourced from the China Securities Market and Accounting Research (CSMAR) database and the official websites of the respective pharmaceutical companies. Excel 2019 is used for preliminary data processing and organization, while STATA 17 is employed for empirical analysis. All continuous variables undergo a winsorization process at the 1% and 99% levels to mitigate the impact of outliers on research conclusions. Consequently, a final unbalanced panel dataset comprising 1,141 firm-year observations is obtained.

Variables Measurement

COD

COD refers to the cost to a firm of borrowing funds from creditors. In this study, the cost of debt is measured using the financial expense ratio, calculated as "financial expenses divided by total liabilities". This accounting-based measure captures the average interest burden across all types of interest-bearing debt and is widely available for listed firms in China. Following Zhang et al. (2021) and Wu et al. (2020), this proxy is practical and suitable for the Chinese context, where bond market participation is limited and credit ratings are often unavailable or unreliable.

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$$COD_t = \sqrt{\frac{Financial\ Expenses_t}{Total\ Liabilities_t}}$$

(Formula 1)

In this formula, CODt represents the COD for the company in period t. Financial Expenses denotes the total financial expenses incurred during period t. Total Liabilities refers to the total liabilities at the end of the period t.

Independent Variable: ED

ED refers to the act of publicly disclosing various activities that impact the environment. It serves as a primary channel through which corporations communicate their environmental responsibilities. In this study, ED is measured using a structured index obtained from the CSMAR database. This index is compiled by CSMAR through the aggregation and standardization of environmental information disclosed by firms across multiple channels, including annual reports, regulatory filings (e.g., environmental penalties), and supplementary ESG reports. The standardized scoring framework ensures cross-firm comparability and consistency, making it a widely adopted source in empirical research on Chinese listed firms.

Following the approaches of Chen, He, and Wang (2023) and Wei, Su, and Sun (2024), the index includes five first-level dimension and each firm's total score is calculated by summing the points assigned to disclosed items (see Table 1). Then standardizing this value by dividing by the maximum possible score of 38. The resulting value, ranging from 0 to 1, is used as the measure of ED in this study. Given that the index is compiled by CSMAR using a standardized methodology, issues related to manual content analysis or inter-coder reliability are not applicable in this context.

Table 1 ED Indicators

Level 1 Indicators	Level 2 Indicators	Evaluation methods
Environmental Management	Environmental Philosophy	0=no description or no events, 1=the information is disclosed or the event has occurred.
	Environmental Objectives	
	Environmental Management System	
	Environmental Education and Training	
	Environmental Initiatives	
	Environmental Contingency	
	Environmental Honors and Awards	
	Three simultaneous	
Disclosure of Environmental Regulation	Pollutant Discharge Compliance	
	Sudden environmental accidents	
	Environmental Violations	
	Environmental petition cases	
Environmental Certification	ISO14001 Certification	
	ISO9001 Certification	
Environmental Liabilities	Wastewater emissions	0=no description, 1=descriptive information
	COD emissions	
	SO2 emissions	
	CO2 emissions	

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	Soot and dust emissions	2=Descriptive information and numerical type of information
	Industrial solid waste emissions	
Environmental Performance and Governance	Exhaust emission reduction treatment	
	Wastewater abatement treatment	
	Control of dust and smoke	
	Solid waste utilization and disposal	
	Noise, light pollution, radiation, and other governance	
	Implementation of Cleaner Production	

Note. Date from CSMAR Database (2023)

Corporate Governance

Corporate governance originates from agency problems and represents a comprehensive institutional framework designed to coordinate economic relationships among various corporate stakeholders, including shareholders, the board of directors, creditors, executives, and employees. Therefore, examining a single governance indicator may not adequately capture the overall corporate governance structure.

To address this limitation, this study constructs a corporate governance index using Principal Component Analysis (PCA), which consolidates variables related to different governance determinants into a single composite score. By incorporating multiple governance characteristics, it mitigates multicollinearity and reduces measurement error through dimensionality reduction. Following the criteria from Zhou et al. (2020) and Wang and Yuan (2022), a corporate governance index based on nine indicators is developed, including: Equity Balance, Institutional Shareholding, Shareholding by Directors, Supervisors, and Executives, Nature of Ownership, Board Independence, Board Size, Supervisory Board Size, Duality, and Executive Compensation. The first principal component, derived from PCA, serves as the composite measure of corporate governance.

First, the data for the nine variables were standardized. The analysis revealed three principal components with eigenvalues greater than 1. Therefore, the first three components are extracted, explaining a cumulative variance of 56.40%. Second, the loading matrix for the nine components is presented in Table 2.

Table 2 Component Loading Matrices

	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7	Comp8	Comp9
Balance	-0.1024	0.2041	0.5919	0.2257	0.6016	-0.4177	0.062	-0.0686	0.0409
INST	0.4498	-0.2366	0.25	-0.4144	0.0314	0.0302	-0.1971	-0.3036	0.6121
NOw	0.387	-0.1806	-0.3516	0.1609	0.2265	-0.1398	0.7615	-0.0157	0.1309
Board	0.3515	0.566	0.0145	0.0209	-0.0662	0.036	-0.0518	0.68	0.2909
Supervisory	0.3304	0.1969	-0.3558	0.2569	0.5168	0.3628	-0.4057	-0.2682	-0.1557
Indep	-0.1759	-0.6184	0.0919	0.2979	0.2603	0.3298	-0.124	0.4946	0.2301
Dual	-0.2829	0.1472	-0.0212	-0.6846	0.4352	0.3801	0.2706	0.1235	-0.0827
Mshare	-0.4495	0.324	-0.0783	0.3108	-0.1033	0.3131	0.1834	-0.3113	0.5925
MComp	0.3026	0.0387	0.5672	0.1765	-0.2155	0.5665	0.2965	-0.1085	-0.2949

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Finally, the formula for measuring the corporate governance index is derived as follows:

$$\mathbf{CG} = (\text{Comp1} * 0.2672 + \text{Comp2} * 0.1629 + \text{Comp3} * 0.1338)/0.5640$$

Control Variables

In examining the impact of ED on the COD, this study plans to use firm profitability, financial leverage, asset turnover ratio, cash flow ratio, revenue growth rate, liquid ratio, and tangible asset ratio as control variables. In addition, the label, measurement, and the source of the variables are provided in Table 3.

Table 3 The Summary of Operationalization of the Variables

Variables	Label	Measurement	Source
COD	COD	Financial expenses divided by total liabilities	CSMAR Database
ED	ED	Standardized ED Score	
Corporate Governance	CG	Included nine variables and was constructed by the PCA.	
Firm Profitability	ROE	Net profit divided by average equity	
Financial Leverage	LEV	Total liabilities divided by total assets	
Revenue Growth Rate	GROWTH	(current year revenue divided by previous year revenue) - 1	
Asset Turnover Ratio	ATO	Operating revenue divided by average total assets	
Cash Flow Ratio	CF	Net cash flow from operating activities divided by total assets at the end of the period	
Liquid Ratio	LIQUID	Current assets divided by current liabilities	
Tangible Asset Ratio	TANGIBLE	(Total assets minus net intangible assets minus net goodwill) divided by total assets	

Estimation Tests

This study employs an unbalanced panel dataset for empirical analysis. Based on the characteristics of the data and the results of the Hausman test, a fixed-effects panel regression model is selected. Additionally, robust standard errors are used to correct for heteroskedasticity in the within-group error terms of the fixed-effects model (Katmon et al., 2019).

Considering the potential reverse causality AND the dynamic persistence, meaning that a firm's current COD might be influenced by its previous value (Huang, Gong, & He, 2023), this study incorporates the lagged dependent variable into the set of independent variables in the original model during the robustness test. A dynamic panel model is constructed and tested using the two-step system Generalized Method of Moments (GMM) estimation, thereby addressing potential endogeneity issues and obtaining more robust empirical results.

Research Model

To test hypothesis H1, we construct Model 1 to investigate the impact of ED on the COD in Chinese listed pharmaceutical companies. To further test hypothesis H2 further, we construct

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Model 2 to investigate the moderating effect of corporate governance on the ED-COD relationship on the COD in Chinese listed pharmaceutical companies.

$$\mathrm{COD} = \alpha_0 + \alpha_1 \mathrm{ED} + \sum \alpha_2 \, \mathrm{Controls} + \varepsilon$$

（Model 1）

$$\mathrm{COD} = \alpha_0 + \alpha_1 \mathrm{ED} + \alpha_2 \mathrm{ED} * \mathrm{CG} + \alpha_3 \mathrm{CG} + \sum \alpha_4 \, \mathrm{Controls} + \varepsilon$$

（Model 2）

COD represents the COD, ED represents ED, CG represents the comprehensive corporate governance index, ED*CG represents the standardized interaction terms between ED (ED) and corporate governance (CG), and ε represents the random error term. Controls represent the control variables, including firm profitability (ROE), financial leverage (LEV), revenue growth rate (GROWTH), asset turnover ratio (ATO), cash flow ratio (CF), liquid ratio (LIQUID), tangible asset ratio (TANGIBLE).

Results and Discussion

Baseline Results

After conducting the Hausman test, we found that the Fixed Effect regression model is more appropriate. Therefore, both regression analyses are based on the results of the fixed effect model in this paper.

In Table 4, the estimated coefficient of the explanatory variable, ED, is -0.00863, which is significantly and negatively correlated with the COD at the 1% significance level. This indicates that an enhanced ED leads to a reduction in the COD. Therefore, hypothesis H1 is supported. This finding is consistent with Fonseka et al. (2020), Zhao and He (2021), Li et al. (2022), Wang and Zhao (2022), Febrinalda and Hasnawati (2022), Morrone et al. (2022) and Tarulli et al. (2023).

This study provides empirical evidence that enhanced ED contributes to a reduction in the COD because, first, as firms operating in a heavily polluting industry, pharmaceutical listed companies in China are subject to stringent environmental compliance regulations. Environmental compliance affects production costs, social acceptance, and government policy support. Consequently, banks and creditors perceive enhanced ED as an indicator of a firm's long-term sustainable operational capability. In this context, companies that proactively disclose more environmental-related information can signal positive prospects to the market and creditors, thereby shaping a favorable corporate image (Xu & Liang, 2024) and ultimately securing lower COD. Second, enhanced ED reflects a firm's compliance and transparency in environmental management, reducing risks associated with environmental violations, such as fines, litigation, or operational disruptions. Creditors can more accurately assess a firm's environmental compliance and operational stability, leading to a lower credit risk premium and default risk premium, thereby decreasing debt financing costs. Finally, with the support of the Chinese government, financial institutions are required to improve green financial management systems by incorporating environmental requirements into comprehensive risk management frameworks and providing policy incentives (e.g., low-interest loans) to green-compliant firms (Securities Times, 2025). Therefore, Chinese pharmaceutical listed companies with

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comprehensive ED are more likely to meet green finance requirements and benefit from the lower COD.

Furthermore, the coefficient of the interaction term between ED and corporate governance is -0.00724, which is significantly and negatively correlated with the COD at the 1% significance level. This suggests that corporate governance acts as a positive moderating variable in the ED-COD relationship. Therefore, hypothesis H2 is supported. This finding is also consistent with Shan (2018).

This is because corporate governance can effectively mitigate and control principal-agent conflicts and information asymmetry. Effective corporate governance helps balance stakeholders' interests (Dang & Lu, 2012), preventing certain internal stakeholders from manipulating the timeliness and accuracy of disclosed information for short-term gains. As a result, effective corporate governance enhances creditors' recognition of the authenticity and transparency of ED, thereby reducing the risk premium and ultimately lowering financing costs. Additionally, effective corporate governance strengthens the internal supervisory role of the board of directors and the supervisory board (Liu & Liu, 2001), discouraging managerial short-termism and encouraging the implementation of long-term environmental strategies. This long-term operational perspective further signals corporate stability to creditors, making them more willing to offer a reduction in the COD.

Among the control variables, both financial leverage and the tangible asset ratio are significantly and positively associated with the cost of debt (COD). Specifically, in both Panel I and Panel II, financial leverage shows a strong positive correlation with COD at the 1% significance level, indicating that higher leverage increases creditors' risk perception and thus raises financing costs. Similarly, the tangible asset ratio is positively associated with COD at the 5% significance level in both panels, suggesting that a higher proportion of tangible assets may not necessarily reduce debt costs, possibly due to overinvestment concerns or asset illiquidity. In contrast, firm profitability and total asset turnover are significantly negatively related to COD. Profitability shows a negative association with COD at the 10% significance level across both panels, reflecting that more profitable firms are likely perceived as less risky by lenders. Likewise, total asset turnover is negatively correlated with COD at the 5% significance level in both models, indicating that operational efficiency contributes to lower financing costs. The revenue growth rate is negatively associated with COD at the 10% significance level in Panel II, but not significant in Panel I, suggesting that its impact on financing costs is not consistent across model specifications. Finally, both the cash flow ratio and the liquidity ratio are positively associated with COD, though the relationships are statistically insignificant, indicating limited explanatory power in this context. These results imply that while liquidity indicators may be relevant in theory, they do not appear to exert a significant influence on debt pricing in the sampled firms.

Table 4 Fixed Effect Regression Results

	COD	COD
ED	-0.00863***	-0.00717***
	(-3.52)	(-2.96)
ED*CG		-0.00724***

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		(-2.61)
CG		-0.00158
		(-1.25)
ROE	-0.00753*	-0.00740*
	(-1.84)	(-1.84)
LEV	0.0284***	0.0281***
	(5.10)	(5.19)
GROWTH	-0.000912	-0.000946*
	(-1.64)	(-1.72)
ATO	-0.00436**	-0.00447**
	(-2.18)	(-2.25)
CF	0.00539	0.00612
	(0.91)	(1.04)
LIQUID	0.000176	0.000164
	(1.25)	(1.17)
TANGIBLE	0.00266**	0.00280**
	(2.16)	(2.35)
_cons	0.00940***	0.00919***
	(4.44)	(4.37)
N	1141	1141
R^2	0.136	0.144
adj. R^2	0.130	0.136
F	8.513	7.654

***, **, and * represent null rejection at 1%, 5%, and 10% level of significance, respectively.
Figures in brackets are t-values.

Robustness Test

Considering that debt financing may exhibit dynamic persistence, the COD in the current period is, to some extent, impacted by the COD in the previous period (Huang et al., 2023). Endogeneity issues may arise from omitted variable bias, so following the studies of Wang (2019) and Huang et al. (2023), this study intends to incorporate the lag-dependent variable and employ the two-step system GMM estimation to obtain robust results.

Table 5 illustrates the results of key variables, and it can be observed that the estimated coefficient of ED is -0.0395, significantly and negatively correlated with the COD at the 1% significance level. This implies that an enhanced ED leads to a reduction in the COD. In addition, the coefficient of the interaction term between ED and corporate governance is -0.0354, significantly and negatively correlated with the COD at the 1% significance level. This indicates that corporate governance acts as a positive moderating variable in the ED-COD relationship.

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Therefore, there are no substantial changes in the sign and significance level of coefficients of the explanatory and moderating variables, which means that the baseline regression results of this study are not severely affected by the existence of endogeneity problems. In summary, the research findings regarding the impact of ED on the COD, as well as the moderating role of corporate governance in this relationship, are robust.

Table 5 Two-Step System GMM Results—Robustness Test

	COD	COD
L.COD	-0.351***	-0.327***
	(0.001)	(0.000)
ED	-0.0395***	-0.0386***
	(0.000)	(0.000)
ED*CG		-0.0354***
		(0.009)
CG		0.00222
		(0.103)
AR(1)	-2.96	-3.56
	(0.003)	(0.000)
AR(2)	-1.21	-1.28
	(0.228)	(0.202)
Hansen	34.64	39.71
	(0.120)	(0.350)

***, ** and * represent null rejection at 1%, 5%, and 10% level of significance, respectively.
Figures in brackets are p-values.

Conclusions

Research on the impact of ED on the COD, with a focus on single-industry firms, has predominantly been conducted in the context of developed economies (Morrone et al., 2022; Tarulli et al., 2023). In contrast, in China, one of the most important emerging markets, existing studies have primarily employed multi-industry samples (Guan & Xiao, 2019; Fonseka et al., 2020; Zhao & He, 2021; Li et al., 2022). Meanwhile, although a limited number of scholars have examined the role of corporate governance in this relationship (Zhao & He, 2021; Zhao, Qu, & Wang, 2023), these studies remain considerably constrained, as they have only addressed the nature of ownership within the ownership structure component of corporate governance. Very limited studies have specifically investigated pharmaceutical companies in China, an industry characterized by both significant environmental impacts and substantial financing needs, which restrains the understanding of the economic motivations underlying ED in representative emerging market economies. Accordingly, this study investigates the economic drivers of CED and examines the potential mediating role of corporate governance within the context of China's pharmaceutical industry.

As the primary source of financing (Fan et al., 2017), changes in the COD can significantly influence firms' practices. The results of this study reveal that enhanced ED is associated with a notable reduction in the COD in Chinese listed pharmaceutical companies. Furthermore,

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corporate governance, defined as a set of mechanisms for managing relationships between firms and their stakeholders (Li & Dai, 2013), is discovered to reinforce the negative ED-COD relationship. This suggests that firms with more effective corporate governance frameworks benefit from a greater reduction in the COD as a result of enhanced environmental disclosure in the context of Chinese listed pharmaceutical firms.

From a perspective of theoretical implications, the findings of this study further enrich the integration of stakeholder theory and signaling theory by providing a more comprehensive explanation of how ED impacts debt financing costs. At the same time, this study extends the applicability of agency theory to the field of environmental disclosure. Specifically, it explores the moderating role of corporate governance in this relationship from the perspective of balancing stakeholder interests (Dang & Lu, 2012) and enhancing the supervisory functions of boards of directors and boards of supervisors (Liu & Liu, 2001).

From a perspective of managerial implications, the findings highlight the incentive-driven nature of ED. In this context, creditors are advised to adopt a long-term orientation by incorporating environmental responsibility as a core criterion in loan approval processes. In addition, financial regulatory authorities, such as the China Securities Regulatory Commission, should integrate the ED situation into the risk assessment frameworks of financial institutions, thereby strengthening creditors' attention to corporate environmental information from an authority level. This is particularly important because pharmaceutical companies, as heavy-polluting firms, face environmental risks that directly influence the credit risk borne by lenders. Creditors can assess firms' environmental accountability and risk exposure by referring to environmental disclosures in corporate reports, thus effectively managing lending risks. The involvement of financial regulators can further enhance creditors' monitoring functions, jointly promoting both improvements in environmental disclosure quality and reductions in firms' debt financing costs. Furthermore, government institutions and corporations should improve corporate governance mechanisms, as effective governance structures foster corporate social responsibility awareness for environmentally friendly development and encourage firms to disclose enhanced environmental information voluntarily. In this regard, pharmaceutical companies in China should standardize their corporate governance structures and optimize internal environmental management practices to control pollution at its source, ultimately improving the disclosure.

Finally, although this study offers valuable theoretical and practical implications, it is subject to certain limitations. First, due to data availability, this study employs ED data provided by the CSMAR database. However, given the growing diversification of disclosure channels, the database may not fully capture all relevant information. For instance, with the rapid rise of new media platforms like TikTok and Xiaohongshu, many firms increasingly release environmental information through these informal channels, which might not be included in the database. Future research could incorporate these new media platforms to build a more comprehensive corporate disclosure database. Second, the exclusion of ST and ST* companies from the sample may introduce sample selection bias, as these firms often face higher financial risks. Including ST companies in future studies could improve the robustness of the findings. Including ST companies in future research could provide a more comprehensive understanding of the ED-COD relationship, as it would allow for a comparison between firms with varying levels of financial health.

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