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THE INFLUENCE OF ENVIRONMENATL REGULATION ON CORPORATE ENVIRONMENTAL DISCLOSURE: THE MODERATING ROLE OF CORPORATE GOVERNANCE

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Abstract:

Corporate environmental information carries significant social externalities, necessitating effective environmental regulation to guide and standardize disclosure practices. Drawing on stakeholder theory, legitimacy theory, and agency theory, this study examines the impact of environmental regulation—perceived by corporates within the regulatory framework—on corporate environmental disclosure while also investigating the moderating role of corporate governance. Based on a panel dataset of 327 listed pharmaceutical companies in China, covering the period from 2018 to 2022, this study employs fixed effects regression analysis to test these relationships empirically. The Generalized Method of Moments (GMM) regression is also applied as a robustness check to address potential endogeneity concerns. The results indicate that intensified environmental regulation significantly promotes corporate environmental disclosure among Chinese pharmaceutical firms. Furthermore, corporate governance is found to positively moderate this relationship, strengthening the effect of environmental regulation on disclosure practices. These findings offer important implications: policymakers should reinforce environmental regulation and improve enforcement mechanisms, while firms should enhance corporate governance structures to further improve their environmental disclosure performance.

Introduction

China's economy has experienced significant growth, expanding from 568.98 billion Yuan at the outset of the reform and opening-up period to 121,020.7 billion Yuan by 2022 (National Bureau of Statistics, 2023), has coincided with a growing environmental crisis. These environmental issues not only pose significant threats to public health but also catalyze social conflicts and tensions (Huang et al., 2019). In this context, companies, especially those in heavily polluting sectors, have come under increasing scrutiny for their environmental performance (Lyu, 2022). Through corporate information disclosure (CED), particularly in relation to environmental matters, both governments and the public can gain a better understanding of firm environmental performance, thereby guiding and incentivizing companies to comply with ERs and fulfill their environmental responsibilities. As a result, CED has become a crucial mechanism for promoting environmental protection at the societal level (Dai & Shi, 2019).

The Chinese government has been continuously strengthening and advancing regulatory documents and requirements concerning corporate environmental supervision. In January 1997, the China Securities Regulatory Commission (CSRC) issued the Provisional Guidelines for the Contents and Formats of Prospectuses, which, for the first time, required listed companies to disclose environmental information related to their business operations. Over the subsequent two decades, government agencies such as the National Environmental Protection Agency, Shanghai Stock Exchanges (SSE) and Shenzhen Stock Exchanges (SZSE), and the Ministry of Environmental Protection have successively released a series of documents to promote and encourage enterprises to adopt more environmentally friendly measures and disclose environmental information. Notably, in December 2017, the CSRC officially promulgated *the Standards for the Content and Format of Information Disclosure by Companies Issuing Securities to the Public No. 2 – Annual Report Content and Format (2017 Revision)*, explicitly mandating that starting in 2018, key pollutant listed companies in China are required to conduct mandatory environmental disclosure. This marked a shift in China's listed companies' environmental disclosure practices from voluntary disclosure to partially mandatory disclosure (Zhang & Ge, 2021). Against this background, with the accelerating development of China's ecological governance system and information disclosure standards, government environmental supervision has gradually evolved into a legalized and institutionalized regulatory framework, placing increasing policy pressure on enterprises to disclose environmental information.

The pharmaceutical industry, a key player in both public health and economic development, is also one of the heavily polluting industries in China. However, its performance in CED remains notably underwhelming. According to the Sino-Securities Index (SNSI), which evaluates firms' environmental practices—including environmental protection measures, resource efficiency, carbon emission control, and pollution management—the average environmental score of pharmaceutical companies between 2018 and 2022 was only 58.47, significantly lower than

the 62.81 average for other heavily polluting industries (as depicted in Table 1). This persistent gap in performance suggests that pharmaceutical firms lag not only in environmental information disclosure but also in broader environmental management. This raises a critical question: why do pharmaceutical firms continue to fall short in CED despite increasing regulatory pressure?

Table 1 Comparison of the Environmental Information Score

Industry	2018	2019	2020	2021	2022	Average
Pharmaceutical	57.36	58.37	58.84	58.49	59.30	58.47
Other Heavily Polluting Industries	61.83	62.63	63.35	62.72	63.51	62.81

Source: Data from SNSI (2023)

While the Chinese government has introduced numerous regulatory measures to improve CED (Liu, 2022), these external ER alone appear insufficient to drive meaningful change within the pharmaceutical industry. This points to the potential limitations of government intervention and the necessity of internal governance mechanisms to effectively translate external pressures into improved corporate behavior. Corporate governance, which encompasses the systems, rules, and processes by which companies are controlled and directed (Lin et al., 1995), ensures the effective operation of internal management systems and promotes better fulfillment of duties by corporate executives and employees (Cui, 2022). Yet, despite its significance, the role of corporate governance in enhancing CED under external ER remains largely underexplored in existing literature.

However, existing studies have primarily focused on heavily polluting enterprises or the manufacturing sector, with limited attention given to the pharmaceutical industry. Moreover, the specific effects of corporate governance in this context have not received sufficient scholarly attention. Therefore, within China's pharmaceutical industry, it remains necessary to examine whether government regulation has effectively promoted CED and whether corporate governance can enhance the impact. Addressing these questions holds significant practical value for improving the environmental disclosure performance of listed pharmaceutical companies in China.

This study seeks to address this gap by focusing on the pharmaceutical industry, a sector that has received limited attention in CED research. Specifically, it investigates how government-enforced ER and corporate governance interact to shape CED practices in China. The study's contributions are twofold: (1) It examines the influence of ER on CED in the pharmaceutical sector following the implementation of partially mandatory disclosure in 2018 (CSRC, 2017), shedding light on how regulatory policies influence disclosure behavior. (2) It explores the role of corporate governance as a comprehensive mechanism—rather than a standalone variable—in enhancing the effectiveness of ER in promoting CED. This approach offers fresh insights into the complex relationship between ER, corporate governance, and CED practices.

Literature Review, Theories and Hypotheses Development

Environmental Regulation and Corporate Environmental Disclosure
Environmental issues exhibit significant externality characteristics and serve as a typical case of market failure, where intensified ER is a crucial approach to mitigate environmental externalities.

In recent years, China has increasingly emphasized CED, actively establishing real-time environmental monitoring systems and disclosure policies, thereby intensifying regulatory oversight of environmental impacts. The government's attitude towards enforcing these regulations and policies is firm and clear, which is considered to be an important influencing factor in improving CED practices in China (Situ et al., 2020; Qian et al., 2022).

Despite the growing body of research, findings on the ER-CED relationship remain inconclusive. On the one hand, some scholars argue that ER does not significantly influence CED. For example, Mchavi (2017), using South African banks as a sample, found that ER had no significant influence on CED. However, this result may be attributable to the distinct characteristics of banks as financial institutions, which differ substantially from those of heavily polluting industries. Similarly, Ji et al. (2019) observed an insignificant positive effect of ER on CED in eight heavily polluting sectors in China. The authors proposed that this is because different local governments with administrative authority vary in their regulatory efforts due to differences in the economy, environmental awareness, and so on. This, in turn, also affects enterprises' willingness to disclose environmental information.

On the other hand, some literatures support a positive influence between ER and CED. In China, to avoid crossing the "red line" of CED, companies in heavily polluting industries invest more in environmental practice as ER intensifies, leading to substantial disclosure of environmental information (He & Ren, 2020). Additionally, to evade penalties and protect corporate reputations, firms are motivated to enhance their CED under heightened ER (Su & Zhang, 2020). Expanding the scope beyond industry-specific samples, He (2024) demonstrated that intensified ER are associated with enhanced CED across all Chinese listed companies. Comparable evidence is found in Vietnam, where Nguyen et al. (2020) revealed that ER exerts the strongest influence on CED among various factors, based on a sample of 120 companies across three industries.

Furthermore, according to stakeholder theory (Freeman, 1984), CED is largely a response to pressure from key stakeholders, including the government, major customers, suppliers, competitors, communities, and the public. Among these factors, ER from government has the most significant impact on corporate behavior, as it directly reflects the pressure exerted by stakeholders. Furthermore, according to legitimacy theory (Deegan & Rankin, 1996), CED practices are a response to environmental pressures (including political, social, and economic pressures). Thus, in order to ensure that corporations fulfill their environmental responsibilities, governments establish environmental regulations that impose supervisory and evaluative pressure on firms. In the Chinese context, the continuous issuance of government documents that expand disclosure requirements and elevate standards highlights how ER acts as a key institutional pressure. As a result, ER drives firms to enhance CED in order to maintain legitimacy (He & Ren, 2020).

However, existing studies exhibit several limitations that warrant further exploration. First, while many studies acknowledge the positive effect of ER on CED, the findings remain mixed, partly due to differences in research contexts and methodologies. Notably, there is limited literature that focuses specifically on the pharmaceutical industry, which is both environmentally sensitive and subject to strict regulatory oversight, and may thus respond differently to ER compared to other sectors. Second, most prior studies do not sufficiently consider the impact of China's partially mandatory environmental disclosure policy introduced in 2018, which significantly altered the regulatory landscape. Overlooking this policy shift may result in outdated or incomplete evaluations of regulatory pressure. Third, few studies account for the regional heterogeneity of ER enforcement across China, despite evidence that local variations in regulatory stringency can substantially influence corporate responses. Finally, while existing studies have adopted panel data approaches, most rely on static estimation techniques that fail to account for the dynamic persistence of CED. By applying the GMM methodology, this study captures the temporal evolution of disclosure behavior and addresses endogeneity concerns, thereby revealing how regulatory frameworks interact with time-varying industry characteristics to shape firms' environmental disclosure strategies.

Therefore, based on stakeholder theory and legitimacy theory, when subject to ER, companies that fail to comply with relevant requirements face not only penalties from regulatory authorities but also potential harm to their public image and a decrease in public approval. As ER intensifies, CED is expected to improve (Su & Zhang, 2020; He & Ren, 2020; Nguyen et al., 2020; He, 2024). Therefore, the following hypothesis (H1) is proposed:
H1: ER has a positive influence on corporate environmental disclosure.

Moderating Effects of Corporate Governance on the Influence of ER on Corporate Environmental Disclosure

Corporate governance is a set of mechanisms designed to coordinate the relationship between enterprises and their stakeholders (Li & Dai, 2013). Due to variations in the intensity of environmental regulation across different regions in China (Ji et al., 2019), the influence of environmental regulation on CED remains somewhat uncertain. Therefore, it is valuable to explore how internal governance mechanisms can enhance the effectiveness of ER in promoting CED.

Corporate governance plays a critical role in shaping firms' CED practices (Ezhilarasi, 2019; Wang & Yuan, 2022). Some studies have highlighted the moderating effect of corporate governance on the ER-CED relationship. Corporation governance variables such as environmental protection consciousness of executive can effectively enhance the influence of ER on CED (Pan & Guo, 2018), which means many existing studies examine corporate governance through isolated mechanisms. However, corporate governance should be seen as an integrated system rather than isolated variables (Tian et al., 2019). Using a composite index to evaluate corporate governance can better reflect the overall governance quality of a firm (Kaur & Vij, 2018), providing a more holistic understanding of its effect on CED. Building on this perspective, empirical research further demonstrates that a composite corporate governance index has a significant positive moderating effect on the relationship between environmental regulation and CED (Tao, 2022).

Despite the growing body of literatures, several important research gaps remain. First, most studies adopt a fragmented approach by focusing on isolated governance variables rather than evaluating corporate governance as an integrated system. Second, contextual factors such as industry-specific environmental sensitivity and regional regulatory disparities in China are overlooked, even though they may critically shape the governance–disclosure nexus. Third, while some prior research identifies potential moderating effects of governance, relatively few studies take a systemic perspective or apply comprehensive index to assess corporate governance effectiveness. To address these gaps, this study constructs a composite corporate governance index and investigates its moderating effect on the ER–CED relationship, with a specific focus on the environmentally sensitive pharmaceutical industry. This approach not only enhances empirical rigor but also offers novel insights into how internal governance mechanisms amplify external regulatory effects.

Based on agency theory (Jensen & Meckling, 1976), enterprises can monitor managerial behavior by establishing mechanisms such as a board of directors. For one, under intensified ER, effective corporate governance enables the board of directors and the supervisory board to perform better internal oversight functions (Liu & Liu, 2001), thereby facilitating managers' formulation of CED requirements. Moreover, corporate governance functions as an internal management mechanism that ensures the effective operation of the company and holds managers and employees accountable for complying with relevant laws, regulations, and internal policies (Cui, 2022). When managers establish CED-related requirements, employees are likely to place increased emphasis on handling the tasks, enabling various departments to more efficiently develop and execute CED processes. These actions may ultimately lead to further CED enhancements. By situating the analysis within a highly regulated industry and emphasizing an integrated governance framework, this study extends the theoretical understanding of how internal governance structures reinforce regulatory effectiveness. Therefore, the following hypothesis (H2) is proposed:

H2: Corporate Governance Has A Positive Moderating Effect On The Influence Of ER On Corporate Environmental Disclosure.

Research Methodology

Sample and Data Considerations
The target sample of this study consists of all the pharmaceutical companies listed on the main boards of the SSE and SZSE in China, categorized under the pharmaceutical industry (C27). This study plans to observe these companies from 2018 to 2022, during which there were 327 listed pharmaceutical companies in China. After excluding companies designated as ST and *ST, as well as those with missing data for key variables, the final sample includes 315 listed pharmaceutical companies. Excluding ST and *ST companies is necessary, as these companies are in abnormal operational states, and their business conditions and disclosure requirements differ from those of normally operating companies. Their data would not be representative and could bias the study's results if included (Fan & Fu, 2021).

The data for this study are sourced from the China Securities Market and Accounting Research (CSMAR) database, provincial government websites, the National Bureau of Statistics, and official websites of listed pharmaceutical companies. In addition, to mitigate the impact of extreme values on the results, this study applied 1% and 99% winsorization to all continuous

data. This process yielded an unbalanced panel dataset comprising 1,167 "company-year" observations.

Variables Measurement

Dependent Variable: Corporate Environmental Disclosure

This study measures CED using the indicator framework provided by the China Environmental Research Database in the CSMAR database and applies content analysis to score the CED of each enterprise, drawing on the research of Chen et al. (2023). Specifically, the indicators on environmental certification (ISO14001 Certification, ISO9001 Certification), environmental management (Environmental Philosophy, Environmental Objectives, Environmental Management System, Environmental Education and Training, Environmental Initiatives, Environmental Contingency, Environmental Honors and Awards, Three simultaneous), and environmental regulatory disclosure (Pollutant discharge compliance, Sudden environmental accidents, Environmental Violations, Environmental petition cases) are scored as 1 if disclosed publicly and 0 if not disclosed. Furthermore, the indicators of environmental liabilities (Wastewater emissions, COD emissions, SO2 emissions, CO2 emissions, Soot, and dust emissions, Industrial solid waste emissions), and environmental performance/environmental 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) involve both the descriptive and numerical type of information. Consequently, for these two indicators, if the evaluation item contains both descriptive information and numerical type of information, it is awarded 2 points. If an evaluation item just contains descriptive information, it receives 1 point. If an item is not disclosed, it receives a score of 0.

The detailed process for calculating the CED variable is as follows (Chen et al., 2023). In the first step, the scores of the 26 indicators for each pharmaceutical listed company are summed up to obtain the CED score (0 being the lowest and 38 being the highest score). In the second step, CED scores are standardized, as CED = Actual CED Score/Maximum CED Score.

Independent Variable: ER

ER refers to environmental oversight and control exercised by local governments. This study builds on the work of Chen and Chen (2018), by using the frequency of relevant vocabulary in government work reports as a proxy variable for ER to more accurately retain the semantic meaning of the original text.

To be specific, in terms of vocabulary selection, this study draws upon the research of Zheng and Xue (2024) and selects 15 words: environmental protection, environmental, pollution, energy consumption, emission reduction, discharge, ecology, green, low carbon, air, chemical oxygen demand, sulfur dioxide SO2, carbon dioxide CO2, PM10, and PM2.5, to comprehensively reflect the government's emphasis on environmental protection. In addition, the ER was calculated by counting the frequency of occurrence of the above vocabularies in the full text of the government report.

Moderator Variable: Corporate Governance

Corporate governance is a set of mechanisms designed to coordinate the relationship between enterprises and their stakeholders (Li & Dai, 2013). Many scholars have employed Principal

Component Analysis (PCA) to construct a corporate governance index that reflects the comprehensive governance status of companies (Wang & Yuan, 2022; Wang & Sun, 2023). Therefore, based on the research related to corporate governance on CED, this study plans to draw on the practice of Zhou et al. (2020) and Wang and Yuan (2022), using the PCA method to analyze the following three dimensions of eight indicators, and select the first major principal component as a variable to measure the corporate governance. Firstly, at the shareholder level, this study selects three indicators, namely, the equity balance, the proportion of institutional shareholding, and the nature of ownership. Secondly, at the board of directors' level, this study selects the four indicators of board independence, the size of the board of directors, the size of the supervisory board, and the dual of the two positions. Finally, this study selects the percentage of executive shareholding and top three management compensation as important indicators to measure corporate governance from the perspective of incentive mechanisms (Lin & Ge, 2023). Based on the above nine variables, the PCA is used to construct corporate governance, and the first principal component obtained from the PCA is used as corporate governance to reflect the level of corporate governance for each company.

The specific steps for calculating the corporate governance in this study are as follows: (1) perform the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity on the nine corporate governance-related variables to determine the feasibility of PCA for these variables. (2) utilize the PCA to extract principal components, selecting variables with eigenvalues greater than 1. (3) combine the extracted principal components into a corporate governance based on the proportion of each principal component's variance contribution to the cumulative variance contribution.

Control Variables

In examining the influence of ER on CED and the moderating effect of corporate governance, this study selects control variables including financial leverage, price-to-book ratio, accounts receivable ratio, book-to-market ratio, bank shareholding, and whether the company is audited by one of the Big Four accounting firms. Label, measurement, and the source of the variables are provided in Table 2.

Table 2 The Summary of Operationalization of the Variables

Variables	Label	Measurement	Source
Corporate Environmental Disclosure	CED	Standardized Corporate Environmental Disclosure Score	CSMAR Database.
ER	GOV	Frequency of Environmental-related Vocabulary in the Government Work Reports of Various Provinces in China	Government Work Reports from Various Provinces.
Corporate Governance	CG	Included nine variables and was constructed by the PCA	CSMAR Database.
Financial Leverage	LEV	Total liabilities divided by total assets	CSMAR Database.
Price-to-Book Ratio	PB	Market price per share divided by net asset value per share	CSMAR Database.

Accounts Receivable Ratio	REC	net accounts receivable divided by total assets at the end of the period	CSMAR Database.
Book-to-Market Ratio	BM	Book value divided by the total market value	CSMAR Database.
Holding Bank Shares	BANK	If the company holds shares of listed or unlisted banks, the value is 1; otherwise, it is 0	CSMAR Database.
Audit by Big Four	BIG4	If a company is audited by a Big Four in a given year, the value is 1; otherwise, it is 0	CSMAR Database.

Estimation Tests

This study employs unbalanced panel data for empirical analysis. Panel data simultaneously consider both cross-sectional and time dimensions, and with a large sample size, it is crucial to first determine the appropriate model form for the panel data. This model effectively addresses issues such as omitted variable bias and multicollinearity, significantly improving estimate precision and estimation efficiency (Su & Zhang, 2020).

To determine the appropriate model for processing and analyzing the panel data used in this study, the F-test, Breusch-Pagan test, and Hausman test must be conducted. Firstly, the p-value is 0.0000 (less than 0.05) in the F-test, indicating that the Fixed Effect (FE) model is more suitable for this study compared to the Ordinary Least Squares (OLS) model. Additionally, in the Breusch-Pagan test, the p-value is 0.0000 (less than 0.05), suggesting that the Random Effect (RE) model is more appropriate for this study compared to the OLS model. Finally, in the Hausman test, the p-value is 0.0000 (less than 0.05), indicating that the FE model is more suitable for this study compared to the RE model. Therefore, the regression analysis in this study will be conducted using the FE model. Therefore, this study will use the fixed effects model for analysis, which is consistent with the research models of Su and Zhang (2020) as well as Chen et al. (2021).

In addition, to address potential endogeneity issues, this study plans to use the Generalized Method of Moments (GMM) regression model for a robustness test. The GMM model includes lagged dependent variables, and by performing internal transformations on the data—subtracting past values from current values—it controls for endogeneity (Roodman, 2009). This selection of robustness test is also aligned with the study by Gerged (2021).

Research Model

To test hypothesis H1, Model 1 is constructed to investigate the influence of ER on CED in listed pharmaceutical companies. To further test hypothesis H2, Model 2 is constructed to investigate the moderating effect of corporate governance on the influence of ER on the CED of listed pharmaceutical companies.

$$CED = \alpha_0 + \alpha_1 GOV + \sum \alpha_2 \, Controls + \varepsilon$$

（Model 1）

$$CED = \alpha_0 + \alpha_1 GOV + \alpha_2 GOV * CG + \alpha_3 CG + \sum \alpha_4 \, Controls + \varepsilon$$

（Model 2）

CED represents corporate environmental disclosure, GOV represents ER, GOV*CG represents the standardized interaction term between corporate governance and regulatory exposure, CG represents the comprehensive corporate governance index, and ε represents the random error term. Control represents control variables including financial leverage (LEV), price-to-book ratio (PB), accounts receivable ratio (REC), book-to-market ratio (BM), whether or not they own shares in a bank (BANK), and whether or not they are Big 4 audited (BIG4).

Results and Discussion

Baseline Regression Analysis

Table 3 presents the regression results for Model 1 and Model 2. In Model 1, ER is used as the explanatory variable, with CED as the dependent variable, analyzing the influence of ER on CED. Model 2 uses ER as the explanatory variable, corporate governance as a moderating variable, and CED as the dependent variable, examining the moderating effect of corporate governance on the relationship between ER and CED. To eliminate the influence of collinearity and dimensional differences, this study standardized the variables before constructing the interaction terms between the independent variables and the moderating variable. Additionally, individual fixed effects were controlled to account for the heterogeneity among different companies.

The regression results from Model 1 indicate that the ER coefficient estimated is 10.16 at a 1% level, which shows the association between ER and CED is significant and positive. Therefore, ER has a positive influence on CED, and hypothesis H1 is validated. This finding is consistent with the studies of Nguyen et al. (2020), He and Ren (2020), Su and Zhang (2020), and He (2024). The reason for this conclusion may lie in the fact that as ER on CED intensifies, companies tend to enhance CED to avoid environmental penalties and mitigate the negative impact on corporate reputation (Su & Zhang, 2020). For the pharmaceutical industry in particular, intensified ER also raises the potential risk of environmental penalties. Between 2018 and 2022, several Chinese pharmaceutical companies faced fines or even suspension of operations due to environmental violations. Consequently, intensified ER compels pharmaceutical companies to pay closer attention to environmental issues and disclose environmental information to gain recognition from stakeholders, such as the government, thereby avoiding penalties and enhancing corporate reputation. Ultimately, for Chinese pharmaceutical listed companies, intensified ER significantly enhances the CED.

In addition, from the regression results of Model 2, it is observed that the coefficient estimated for ER is 10.78 (at the 1% level), which shows a positive and significant association between ER and CED. Additionally, the coefficient estimated for the interaction term between ER and corporate governance is 14.40, which is significant at a 5% level. This suggests that corporate governance can enhance the influence of ER on CED. Therefore, the hypothesis H2 is validated. This finding is also consistent with the Tao's study (2022). This also implies that under ER, Chinese pharmaceutical listed companies must further improve their corporate governance effectiveness to enhance CED. This is particularly critical because, at present, China lacks specific environmental disclosure standards tailored to pharmaceutical listed companies (Xiao, 2024). As a result, enterprises need internal drivers to further enhance CED. Effective corporate governance can strengthen internal oversight and ensure that managers and employees comply with government requirements to complete enhanced CED. To achieve sustainable and healthy development, companies must actively fulfill their environmental responsibilities while

disclosing, thereby responding to ER and avoiding accountability. Ultimately, corporate governance plays a significant positive role in enhancing the influence of ER on CED for Chinese listed pharmaceutical companies.

Table 3 Baseline Regression Results

	Model 1	Model 2
GOV	10.16***	10.78***
	(2.77)	(2.95)
GOVCG		14.40**
		(2.33)
CG		0.0394***
		(2.71)
LEV	0.103**	0.105**
	(2.27)	(2.33)
PB	-0.0122***	-0.0120***
	(-6.19)	(-6.14)
REC	-0.195*	-0.199*
	(-1.84)	(-1.88)
BM	-0.0742**	-0.0738**
	(-2.28)	(-2.28)
BANK	-0.127**	-0.130**
	(-2.16)	(-2.21)
BIG4	0.175***	0.159***
	(4.97)	(4.47)
_cons	0.304***	0.301***
	(8.57)	(8.54)
N	1167	1167
adj. R^2	-0.224	-0.21
F	13.07	11.66

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

Robustness Test

To address endogeneity issues, this study plans to employ the two-step system GMM method for dynamic panel analysis to obtain robustness in the test results (Alipour et al., 2019; Gerged, 2021). Table 4 shows all models incorporate CED lag as an independent variable. Model 1 presents regression data with ER as the explanatory variable and CED as the dependent variable. Model 2 shows regression data with ER as the explanatory variable, corporate governance as the moderating variable, and CED as the dependent variable.

From the regression results of Model 1, it can be observed that the coefficient estimated for ER is 50.41, with a significance of 0.000 ($p < 0.01$). This indicates that the CED has significantly enhanced with the intensifying of ER.

From the regression results in Model 2, it can be observed that the estimated coefficient of ER is 48.39, with a significance of 0.000 (p < 0.01). Simultaneously, the coefficient estimate of the interaction term between ER and corporate governance is 20.84, with a significance of 0.013 (p < 0.05), indicating that corporate governance can strengthen the influence of ER on CED.

Therefore, as indicated by the results in Table 4, the signs and significance of the coefficients of each variable have not fundamentally changed. This suggests that the regression results regarding the influence of ER on CED, and the moderating effect of corporate governance in this relationship are reasonably robust.

Table 4 Results of Two-Step System GMM Estimations

	Model 1	Model 2
L.ED	0.323***	0.304***
	(0.001)	(0.002)
GOV	50.41***	48.39***
	(0.000)	(0.000)
GOV*CG		20.84**
		(0.013)
CG		0.0579***
		(0.000)
Lev	0.0809*	0.0927**
	(0.068)	(0.029)
PB	-0.00435	-0.00406
	(0.164)	(0.185)
REC	-0.282***	-0.291***
	(0.004)	(0.005)
BM	-0.0346	-0.0267
	(0.403)	(0.525)
Bank	-0.191	-0.189
	(0.165)	(0.189)
Big4	0.145***	0.114***
	(0.000)	(0.000)
_cons	-0.0592	-0.0464
	(0.358)	(0.470)
AR(1)	-5.85	-5.8
	(0.000)	(0.000)
AR(2)	1.56	1.5
	(0.119)	(0.133)
Hansen	3.77	3.61
	(0.152)	(0.164)

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

Conclusions

This study uses Chinese pharmaceutical companies listed from 2018 to 2022 as the research sample, first examining the influence of ER on CED. Additionally, it empirically tests the moderating effect of corporate governance on the relationship between ER and CED.

For one, ER, which refers to environmental oversight and control exerted by local governments, is a key factor influencing CED. Drawing on Zheng and Xue (2024), this study uses the frequency of relevant terms in provincial government work reports as a proxy variable for ER. Results show that Chinese pharmaceutical companies listed with intensified ER have enhanced CED. This finding aligns with the studies of Nguyen et al. (2020), He and Ren (2020), Su and Zhang (2020), and He (2024). This implies that Chinese pharmaceutical companies, as heavily polluting enterprises, are particularly subject to stringent government ER. The intensified ER compels these companies to pay greater attention to environmental issues and disclose environmental information, thereby gaining recognition from stakeholders, such as the government, ultimately avoiding penalties and enhancing corporate reputation.

Moreover, corporate governance can amplify the positive impact of ER on corporate environmental disclosure (CED), which aligns with the findings of Tao (2022). Effective corporate governance strengthens internal information disclosure processes (Cui, 2022) and better internal oversight functions (Liu & Liu, 2001). This ensures that managers and employees adhere more effectively to government regulations for completing enhanced CED. By doing so, companies can achieve sustainable and healthy development, actively fulfill their environmental responsibilities, and conduct enhanced CED to comply with government regulations and avoid accountability. Therefore, under intensified ER, Chinese pharmaceutical listed companies must further increase corporate governance effectiveness to enhance CED.

These findings bring some theoretical implications. First, based on stakeholder theory, this study incorporates the perspective of stakeholders by selecting ER, representing the government, as a variable. Combined with legitimacy theory, it examines the influence of ER on CED, offering a richer theoretical perspective to explore CED influencing factors. Second, prior studies have largely overlooked the role of corporate governance in further enhancing the influence of ER on CED from within the enterprise, leaving a gap in the application of agency theory. This study examines the moderating effect of corporate governance on the relationship between ER and CED, further deepening the understanding of the role of corporate governance within the framework of agency theory.

In addition, based on the above research findings, this study offers the following two recommendations from both governmental and internal corporate perspectives:

(1) The government should intensify ER and improve related institutional frameworks. Provincial governments should rigorously monitor pharmaceutical companies' environmental practices, ensuring these companies fulfill their environmental responsibilities and actively disclose high-quality environmental information. Additionally, the government should implement a clear system of rewards and penalties. Companies that voluntarily adhere to policies and disclose high-quality environmental information should receive appropriate rewards, while those with environmental violations or insufficient disclosure practices should face stringent penalties. In addition, the Chinese government should appropriately revise a series of laws and regulations to further enhance the requirements for CED by pharmaceutical

listed companies. Specific provisions should mandate pharmaceutical companies to disclose detailed and comprehensive environmental information, including the specific composition of highly polluting raw materials and reagents used in the production process. Furthermore, companies should provide thorough explanations of pollution control measures and their outcomes. This would improve the comparability of environmental information across different pharmaceutical companies while also establishing a credible evaluation system for CED.

(2) An effective corporate governance system encourages companies to disclose better environmental information. This also enhances the accuracy, completeness, and reliability of disclosed environmental data, ensuring the quality of CED. Establishing comprehensive governance regulations and a well-rounded governance management system is crucial for corporations. Firstly, companies can optimize their ownership structure (e.g., the shareholding ratio of major shareholders, institutional investors, and management) to find a balanced structure suitable for their development. Secondly, expanding the board and supervisory board allows companies to incorporate more regulatory insights, refine decision-making processes, and improve decision-making efficiency. At the same time, increasing the proportion of directors and supervisory board members with a pharmaceutical background to strengthen their capabilities enables management to be incentivized and constrained. Thirdly, refining the management compensation and incentive system, such as implementing reward and penalty mechanisms and creating reasonable pay differentials within management, can encourage management's environmental awareness and commitment to CED. Fourth, firms should establish dedicated environmental management departments and provide specialized training for accounting professionals with expertise in the pharmaceutical industry. Chinese pharmaceutical listed companies should create specialized environmental management departments and assign individuals with pharmaceutical backgrounds to oversee CED. Given the industry's characteristics, including high volumes of various pollutant emissions and prominent pollution issues (Wang, 2020), Chinese pharmaceutical enterprises should set up specialized departments to document and organize environmental issues across every stage of the production process. This approach can better help companies improve production processes while simultaneously collecting environmental information.

Finally, while the study holds some significance, it still faces limitations due to a relatively small sample size. As the sample comprises only listed pharmaceutical companies in China, the findings may not be universally applicable across all industries and all countries. Additionally, missing data led to the exclusion of certain samples, further reducing the sample size and potentially affecting the reliability of the results. Thus, future research could focus on larger, cross-industry, or cross-country samples. Expanding the scope to encompass all high-pollution industries or even a full-industry sample would help test the generalizability of these findings.

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