



Informal Environmental Regulation and Corporate ESG Performance

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Abstract. In recent years, the environment, society, and governance have played an increasingly important role in the development of enterprise operations. However, the driving factors of ESG performance have not been fully studied. This paper takes China's A-share listed companies in Shanghai and Shenzhen from 2011-2021 as a sample, and theoretically analyzes and empirically tests the impact of informal environmental regulation on enterprise ESG performance. The research results show that informal environmental regulation has a significant positive impact on enterprise ESG performance, which is still valid after multiple robustness tests and endogenous tests. We verified that executive environmental awareness has a moderating effect on the relationship between informal environmental regulations and ESG performance. Further analysis indicates that the research findings are more pronounced for companies with high reputation and high analyst coverage. Our research enriches the literature on ESG driving factors and highlights the supervisory role of informal environmental regulations in promoting sustainable development of enterprises.

Keywords: Informal environmental regulation; ESG; Environmental investment; Executive environmental awareness

1 Introduction

With the rise of green governance concepts worldwide, the issue of sustainable economic development has attracted widespread attention. As the fundamental unit of economic development, the quality and efficiency of enterprise development determine the depth and breadth of economic sustainability. ESG, as a comprehensive evaluation indicator for measuring the environmental, social, and governance aspects of enterprises, is in line with China's sustainable development concept of promoting green development, enhancing people's well-being, and improving social governance. Actively improving enterprise ESG performance is an effective path to achieve sustainable economic development in China. Due to the unique environmental regulations of local governments in China, there are issues such as inadequate regulation, which lack consistency in their impact on corporate ESG performance[1](Li M et al.,2021). There are limitations in exploring the impact of institutional policies on ESG performance. Few

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scholars have explored the impact of informal environmental regulations on corporate ESG performance from a public perspective. Therefore, this article focuses on whether informal environmental regulations are an important external supervision mechanism that can affect corporate ESG performance.

In recent years, informal environmental regulations have gradually received attention from scholars [2] (Du et al.,2023). The main determining factor of informal environmental regulation comes from the public's environmental needs. With the gradual enhancement of public environmental awareness, the public expresses their dissatisfaction with environmental governance through complaints, marches, and other means to the government [3] (Kathuria,2007). The public provides effective information to the government and cooperates with government departments to supervise and inspect polluting enterprises, in order to curb their pollution behavior [4,5] (Dong et al.,2011; Liu and Mu, 2016). Therefore, informal environmental regulations have become an important means to compensate for the failure of formal environmental regulations. On this basis, the impact of informal environmental regulations on the sustainable development of enterprises, especially ESG performance, was examined. This article demonstrates through theoretical analysis and empirical testing that informal environmental regulations have a promoting effect on ESG performance, and executive environmental awareness can actively regulate the relationship between the two. However, informal environmental regulations have a more significant promoting effect on ESG performance of companies with high reputation and high analyst coverage. After robustness testing, the results are still significant.

Our research contribution is as follows: Firstly, it enriches the research on the economic consequences of informal environmental regulation and the driving factors of corporate ESG performance. At present, literature research mainly focuses on formal environmental regulations, such as pollution fees and environmental protection taxes [6,7] (Wang et al., 2019; Fang et al., 2023). There is relatively little discussion on the economic consequences of informal environmental regulations. At the same time, existing research mostly explores the economic consequences analysis of ESG performance, and there is insufficient exploration of the driving factors of ESG performance. This article attempts to explore the impact of third-party informal regulation on ESG performance, which has certain practical value. Secondly, this article incorporates executive environmental awareness as a moderating variable into the research framework, exploring the moderating effect of executive environmental awareness. The aim is to explore more comprehensively the differences in the impact of informal environmental regulations on corporate ESG performance, and provide new explanatory ideas for implementing ESG strategies for enterprises.

The structure of other parts of this article is as follows. In the second section, we reviewed relevant literature and proposed research hypotheses. The third section involves data selection, variable definition, and model construction. The fourth section introduces the robustness test, mechanism analysis, and further analysis. Finally, the fifth section provides a summary of this study.

2 Literature Review and Hypothesis Development

2.1 The Impact of Informal Environmental Regulations

When formal environmental regulations fail or lack policies, the public, media, and environmental organizations negotiate with polluting enterprises to achieve emission reduction and environmental protection goals [8] (Pargal and Wheeler,1996).The impact of informal environmental regulations on government environmental governance can be mainly divided into two paths: first, the public reports pollution information to higher-level governments through environmental protection petitions, online platform public opinion, video dissemination, and public channels [9] (Deng et al.,2023). Zheng et al. (2013) found that the public's environmental demands through the official performance evaluation system can help local governments increase investment in environmental governance[10]. The higher the public's environmental complaints, the stronger the local government's efforts to collect corporate pollution fees, and the stricter the implementation of environmental regulations. Therefore, as the third party non-mandatory supervision mechanism, informal environmental regulation can effectively promote enterprises and relevant government departments to engage in environmental responsibility behaviors.

2.2 The Determinants of ESG Performance

ESG performance has gradually become a non-financial indicator for measuring a company's sustainable development ability from three aspects: environmental, social, and corporate governance. Excellent ESG performance and rating can establish a good image for a company, enhance its reputation, attract investor attention, alleviate financing constraints, enhance transparency between internal managers and investors, and increase returns in the capital market [11] (Eichholtz et al.,2019).

The driving factors of enterprise ESG performance mainly include external and internal factors. On the one hand, external factors are pressure from the government, mainly driven by tools such as laws and regulations, policy uncertainty, and market supervision [12] (McWilliams et al.,2006). On the other hand, external pressure comes from stakeholder supervision, such as the attention of institutional investors and analysts, as well as the media and the public. Internal driving factors only need to focus on the corporate structure, such as the proportion of female executives, board structure, and digital transformation strategies of the enterprise [13] (Yan et al.,2024).

2.3 Development of Assumptions

Informal environmental regulations deepen corporate governance structure reform by increasing the cost of corporate environmental violations, enhancing corporate green governance capabilities, and fulfilling corporate social responsibilities, thereby promoting the improvement of corporate ESG performance. The public exerts pressure on the government to express their environmental demands through letters, phone reports, and other means, and resists companies that produce products that harm the environment

and affect their profitability [14] (Zhang et al.,2022). Enterprises with serious environmental violations may also face administrative fines and litigation costs, and the high cost of environmental violations caused by public supervision will force them to take environmental governance actions [15] (List and Sturm,2006). Informal environmental regulations represent legal constraints at the social level, promoting companies to pay attention to environmental protection and fulfill social responsibilities through various forms [14] (Zhang et al.,2022). Based on external environmental pressures, companies will take the initiative to assume social responsibility and change behaviors that are harmful to stakeholders in order to avoid negative impacts such as reputation decline [16] (Carmichael and Brulle,2017). There is a spillover effect of corporate social responsibility fulfillment when improving environmental performance, that is, emphasizing social responsibility fulfillment while protecting the environment. Informal environmental regulations guide enterprises to strengthen self supervision, reduce opportunistic behavior, safeguard the interests of stakeholders, constrain the behavior of managers, promote more standardized internal controls, and better achieve corporate governance goals [17] (Luo and Bhattacharya,2006). Therefore, the first assumption is as follows:

H1: Informal environmental regulations can significantly improve corporate ESG performance.

Based on the high-order echelon theory, the background characteristics, values, and thinking patterns of corporate executives have a significant impact on organizational decision-making and economic benefits [18] (Hambrick and Mason,1984). The perception of external pressure by executives, as well as the identification of external risks and opportunities, can affect a company's ESG strategy [19] (Mahran and Elame,2024). When facing public environmental demands and public opinion, the environmental awareness of executives can help them achieve production and operation performance higher than the minimum requirements of environmental regulatory policies, actively pay attention to the latest trends in the public's preferences for green products, grasp and obtain information and knowledge to achieve sustainable green development, timely adopt green production strategies to reduce pollution emissions of enterprises, actively improve corporate environmental performance to meet public demands. Executives with a high level of environmental awareness not only pay attention to corporate environmental issues, but also enhance their attention to corporate social responsibility, including the green demands of employees, communities, consumers, and suppliers. Executives with a high level of environmental awareness pay more attention to the long-term sustainable development of the enterprise, incorporate low-carbon innovative development into the strategic height [20] (Tseng et al.,2013), actively disclose ESG information, and supervise and manage the sustainable development issues of the enterprise itself through the establishment of ESG committees and other means, improving the ESG performance of the corporate governance dimension. Therefore, we propose the following hypothesis:

H2: Executive environmental awareness has a positive moderating effect on the relationship between informal environmental regulations and ESG performance.

3 Methodology

3.1 Data Sources

This paper selects A-share listed companies in 2011-2021 as the research sample. Considering the implementation of special accounting standards in the financial industry, we exclude listed companies in the financial industry; Exclude companies that are unable to obtain relevant financial data; Exclude ST and *ST companies with abnormal financial data; To reduce the impact of extreme values, Winsorize truncation was applied to all continuous variables at the 1% and 99% quantile levels. In this study, ESG data was sourced from the Huazheng ESG evaluation database, while informal environmental regulation data was sourced from the Baidu search index. The remaining financial data is sourced from the WIND database and the CSMAR database. Finally, 21128 data observations were obtained, and the data processing software used in this article is Stata17.0.

3.2 Variable Definition

3.2.1 Dependent Variable

ESG performance (*ESG*), this paper refers to previous research [9](Deng et al.,2023), and uses the Huazheng ESG rating system data as the dependent variable in the benchmark model. The ESG comprehensive rating is mainly divided into nine levels: AAA, AA, A, BBB, BB, B, CCC, CC, and C. This article assigns values from 9 to 1, with higher values indicating better ESG performance of the enterprise.

3.2.2 Independent Variables

Informal Environmental Regulation (*IER*), this paper refers to previous research [10,21] (Xu,2014; Zheng et al.,2013), and will use social pressure as the measure of IER. The Baidu index of residents searching for specific environmental keywords will be selected to construct a public environmental attention index. The specific approach is to conduct keyword search in Baidu search engine, and use python tools to crawl the search volume of environmental protection terms from 2011 to 2021. The environmental protection terms refer to 27 words of Zhang and Chen (2021) [22], including "environmental protection", "environmental protection", "green", etc. The sum of PC and mobile devices is added up and taken as the natural logarithm, which serves as a proxy variable for informal environmental regulation.

3.2.3 Control Variables

This paper refers to existing research [23] (Zhang and Wu,2023), and selects enterprise size (*Size*), enterprise age (*Age*), Tobin Q value (*Tobin q*), operating cash flow (*Cashflow*), institutional investor shareholding ratio (*Inst*), major shareholder shareholding ratio (*Top1*), asset return on investment (*Roa*), growth (*Growth*), dual role integration (*Dual*), industry effect (*Ind*), and time effect (*Year*) as control variables. In

addition, we have introduced formal environmental regulations (*Er*) to control the policy impact at the provincial level.

3.3 Model

The Eq. (1) presents our baseline empirical model:

$$ESG_{i,t} = \alpha_0 + \alpha_1 IER_{i,t} + \alpha_i Control_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t} \quad (1)$$

where the subscripts *i* and *t* denote the firm and year, respectively. $\varepsilon_{i,t}$ is the random error term in the benchmark model. This article reports on the standard error of clustering robustness at the enterprise level. If α_l is significantly positive, it indicates that informal environmental regulations have a positive impact on ESG, and hypothesis H1 is valid.

4 Empirical analysis

4.1 Descriptive Results

According to the descriptive statistical analysis results in Table 1, the maximum ESG performance rating of enterprises is 9, and the minimum value is 1. The large range indicates a significant gap in ESG performance among Chinese enterprises, with a mean of 4.172, indicating that the ESG performance of Chinese enterprises needs to be improved. The minimum value of informal environmental regulation intensity is 0.057 and the maximum value is 0.712, indicating that there is high heterogeneity in the informal environmental regulation intensity in different provinces and years. The above data lays a good research foundation for the regression analysis of this article.

Table 1. Descriptive statistics of main variables

Variable	N	Mean	Max	Min	Median	SD
<i>ESG</i>	21128	4.172	9.000	1.000	4.000	1.051
<i>IER</i>	21128	0.386	0.712	0.057	0.392	0.158
<i>Er</i>	21128	0.326	0.505	0.140	0.320	0.082
<i>Size</i>	21128	22.236	26.209	19.951	22.047	1.295
<i>Lev</i>	21128	0.427	0.891	0.053	0.420	0.206
<i>Roa</i>	21128	0.043	0.214	-0.191	0.040	0.058
<i>Tobinq</i>	21128	2.042	8.464	0.871	1.611	1.300
<i>Cashflow</i>	21128	0.045	0.232	-0.150	0.044	0.067
<i>Growth</i>	21128	0.182	2.499	-0.495	0.116	0.393
<i>Dual</i>	21128	0.265	1.000	0.000	0.000	0.441
<i>Inst</i>	21128	0.456	0.935	0.004	0.475	0.251
<i>Top1</i>	21128	0.347	0.743	0.009	0.328	0.148
<i>Age</i>	21128	2.861	3.466	1.792	2.890	0.328

4.2 Baseline Results

The benchmark regression results of informal environmental regulations and corporate ESG performance are shown in Table 2. Among them, column (1) represents the regression results without the inclusion of control variables, column (2) represents the regression results with the inclusion of enterprise level control variables. In column (3), the regression results with the inclusion of year and industry fixed effects are significantly positive, indicating that the main effect results have a certain degree of robustness. The research H1 has been preliminarily validated.

Table 2. Results of informal environmental regulation and enterprise ESG performance

	(1)	(2)	(3)
	<i>ESG</i>	<i>ESG</i>	<i>ESG</i>
<i>IER</i>	0.539*** (11.84)	0.429*** (9.54)	0.261*** (4.90)
<i>Controls</i>	Yes	Yes	Yes
<i>_cons</i>	3.965*** (208.83)	-0.344** (-2.14)	-1.638*** (-8.24)
<i>N</i>	21128	21128	21128
<i>Ind / Year</i>	No	No	Yes
<i>R</i> ²	0.007	0.124	0.194

Note: *, **, and *** denote significance level of 10%, 5%, and 1%, respectively.

4.3 Robustness Tests

4.3.1 Alternative ESG Measurement

In order to control for potential bias in research conclusions caused by measurement errors of key variables, Bloomberg ESG rating data was used to re measure ESG performance and record it as *ESG_pbs*. The ESG rating score obtained by Bloomberg based on the degree of ESG information disclosure of the enterprise is 0-100, with each sub item score divided by 10. The higher the level of corporate disclosure and the higher the score, the lower the ESG risk. The regression results are shown in Table 3. After replacing the ESG measurement method, column (1) still shows a significant positive correlation at the 1% level, the research conclusion of this article is still valid.

4.3.2. Alternative PEC Measurement

Based on the concept of environmental regulation proposed by Parga and Wheeler (1996), this article selects a series of comprehensive indicators such as income level, education level, population density, and age structure, and uses entropy method to construct the intensity of informal environmental regulation in each province (*IER_adj*). The regression results are shown in Table 3 column (2), After replacing the measurement method, the research conclusion of this article is still valid.

Table 3. Regression results of robustness tests

	(1)	(2)
	<i>ESG pbs</i>	<i>ESG</i>
<i>IER</i>	1.853*** (3.65)	
<i>IER_adj</i>		0.106** (2.30)
<i>Controls</i>	Yes	Yes
<i>_cons</i>	-32.853*** (-17.51)	-1.493*** (-7.30)
<i>N</i>	8383	19818
<i>Ind / Year</i>	Yes	Yes
<i>R²</i>	0.322	0.195

Note: *, **, and *** denote significance level of 10%, 5%, and 1%, respectively.

4.4 Endogeneity

4.4.1 Instrumental Variable Regression

In order to alleviate endogenous problems, this section takes provincial *Internet IV* and *Tel IV* as tool variables of informal environmental supervision. Table 4 reports the regression results of 2SLS after controlling for endogeneity issues. Column (1) is the regression result of the first stage. The *Internet IV* and *Tel-IV* are significantly positively correlated at the level of 1%, which is in line with the expectations of this article. Column (2) shows the regression results of the second stage, and the weak instrumental variable results show that the F-value in the first stage is much greater than 10, indicating that the instrumental variable selected in this article is not a weak instrumental variable and has a strong correlation with the endogenous explanatory variable. The P-values of the over identification test are all greater than 0.05, indicating that there is no over identification problem.

4.4.2 Propensity Score Matching Test

This article adopts the propensity score matching (PSM) method to control for systematic differences caused by different levels of informal environmental regulation, eliminate the problem of sample self selection, and enhance the robustness of the research conclusions. Construct the following matching model based on logit regression and use kernel density matching. Substitute the matched samples into the model for regression, and the regression results are shown in Table 4 Column (3). The regression coefficient is significantly positive at the 1% level, further indicating the robustness of the research conclusion in this article.

Table 4. Endogeneity test regression results

	(1)	(2)	(3)
	<i>IER</i>	<i>ESG</i>	<i>ESG</i>

<i>IER</i>		0.342*** (5.44)	0.262*** (4.90)
<i>Tel-IV</i>	0.661*** (139.18)		
<i>Internet-IV</i>	0.138*** (193.26)		
<i>Controls</i>	Yes	Yes	Yes
<i>_cons</i>	-0.828*** (-57.38)	-1.638*** (-8.27)	-1.638*** (-8.24)
<i>N</i>	21128	21128	21124
<i>R</i> ²	0.831	0.194	0.194
Weak instrumental variable test	F=26358.1 (P=0.0000)		
Overidentification test	P=0.2627		

Note: *, **, and *** denote significance level of 10%, 5%, and 1%, respectively.

4.5 Moderating Effect Test

To test H2, the article uses the ratio of the frequency to total frequency ratio of keywords related to environmental attention in MD&A articles of management was used to measure executive environmental awareness. This includes the company's interpretation and analysis of important information for the current period, as well as the next year's business plan, opportunities, challenges, and risk defense faced by the company's development, fully reflecting the understanding and attention of executives to the company's strategy. The higher the frequency of words, the stronger the environmental awareness of managers. The regression results are shown in Table 5, and the *IER* × *Mea* coefficient is significantly positive at the 1% level, indicating that *Mea* has a positive regulatory effect.

Table 5. Moderating effect test results

	(1) <i>ESG</i>	(2) <i>ESG</i>	(3) <i>ESG</i>
<i>IER</i>	0.313*** (4.38)	0.269*** (3.92)	0.162** (2.19)
<i>Mea</i>	-0.625*** (-4.02)	-0.511*** (-3.46)	-0.166 (-1.11)
<i>IER</i> × <i>Mea</i>	1.593*** (4.06)	1.092*** (2.95)	0.721** (1.97)
<i>_cons</i>	4.056*** (135.19)	-0.294* (-1.82)	-1.627*** (-8.16)
<i>N</i>	21128	21128	21128
<i>Ind / Year</i>	No	No	Yes
<i>R</i> ²	0.007	0.125	0.195

Note: *, **, and *** denote significance level of 10%, 5%, and 1%, respectively.

4.6 Further Research

4.6.1 Heterogeneity Testing Based on Corporate Reputation

With the increasing public demand for environmental protection, when a company's pollution behavior has a negative impact, the "publicity effect" of the company's reputation sends a signal of quality assurance to the market. The higher the reputation of a company, based on the principle of risk avoidance, the more motivated it is to fulfill its social responsibility and improve its innovation level, which will enhance its ESG performance to cope with potential business risks. This article selects 12 reputation evaluation indicators and uses factor analysis to calculate reputation scores. The enterprise reputation scores are divided into ten groups from low to high, and Rep values are assigned from 1 to 10 in order. The coefficient of *IER* for the group with high reputation is significant at the 1% level. This indicates that informal environmental regulations have a stronger effect on enhancing ESG of reputable enterprises. The regression results are shown in Table 6 Column (1)(2).

4.6.2 Heterogeneity Testing Based on Analyst Coverage

Analysts are more inclined to focus on companies with good ESG performance [24] (Pástor et al.,2021). Analysts guide the media to expand the dissemination of corporate ESG information, increase public awareness of corporate ESG, enhance information transparency, and reduce financing costs to attract ESG investment by writing reports. At the same time, analysts cover and supervise the implementation of corporate environmental policies, increase the importance of employee welfare, and reduce opportunistic behavior in enterprises. [25] (Bradley et al.,2021). This article uses the number of research reports released by analysts who track enterprises within a year plus 1 to take the natural logarithm as the measurement indicator of analyst attention. The regression results are shown in Table 6 Column (3)(4). In a group with high analyst coverage, there is a significant positive correlation

Table 6. Heterogeneity test regression results

	(1)	(2)	(3)	(4)
	<i>Rep=0</i>	<i>Rep=1</i>	<i>Cov=0</i>	<i>Cov=1</i>
	<i>ESG</i>	<i>ESG</i>	<i>ESG</i>	<i>ESG</i>
<i>IER</i>	0.103 (1.27)	0.366*** (5.13)	0.038 (0.49)	0.395*** (5.26)
Controls	Yes	Yes	Yes	Yes
<i>_cons</i>	-1.568*** (-5.15)	-1.654*** (-2.83)	0.651* (1.93)	-1.810*** (-6.70)
<i>N</i>	9185	11943	10350	10778
<i>Ind/ Year</i>	Yes	Yes	Yes	Yes
<i>R2</i>	0.224	0.175	0.173	0.182
Permutation		0.0132**		0.0007***

Note: *, **, and *** denote significance level of 10%, 5%, and 1%, respectively.

5 Conclusion

Informal environmental regulation is an effective supplement to the government's inadequate regulation. This paper studies the impact of informal environmental regulation on enterprise ESG performance, and selects Chinese A-share listed companies in Shanghai and Shenzhen in 2011-2021 as the research object. The empirical results show that informal environmental regulation can improve enterprise ESG performance, and the higher the environmental awareness of executives, the more obvious the promotion effect. We further demonstrate that the promotion effect of informal environmental regulations on companies with high reputation and analyst coverage can enhance their ESG performance. Based on the above conclusions, we propose the following insights:

Firstly, the government should attach importance to public environmental supervision and enhance support for enterprise greening; At the same time, further improve the existing environmental regulations and policies, enhance legal constraints on environmental protection, eliminate the incidence of collusion between government and enterprises, and avoid the government's own resource allocation tilting towards short-term low economic quality.

Secondly, enterprises should strengthen their environmental responsibility, establish a sense of sustainable development, attach importance to the executive training system, and improve their internal governance mechanisms. Integrate the development of ESG concepts with corporate management concepts, promote enterprises to actively assume environmental and social responsibilities, actively improve internal governance mechanisms, and enhance their competitiveness.

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