

Article

Environmental Information Disclosure and Corporate Green Innovation: The Moderating Effect of Formal and Informal Institutions

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Abstract: Green innovation has been recognized as a strategic priority to build competitive advantage, but few studies have examined the impact of environmental information disclosure on green innovation in emerging economies. By integrating the stakeholder and institutional theories, this study explores the relationship between environmental information disclosure and green innovation under formal and informal institutions. Using the panel data of Chinese A-share listed companies from 2009 to 2021, the findings reveal that environmental information disclosure positively affects corporates' green innovation. Further, this research finds that this positive effect is strengthened by the formal institution (proxied by the institutional environment) but weakened by the informal institution (proxied by political connection). Results are valid after addressing the potential endogeneity problem and remain unchanged in robustness tests. This study's findings affirm the decision usefulness of environmental information disclosure that corporates can use as an effective strategy to promote green innovation.

Keywords: green innovation; environmental information disclosure; formal institution; informal institution; corporate strategy



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1. Introduction

As global environmental pollution and carbon emissions increasingly challenge firm production and ecosystems, green innovation is regarded as an effective way to reduce negative environmental impacts and achieve sustainable green growth. However, due to the excessive R&D expenses and externalities related to green innovation, corporates lack incentives to enforce it actively. In the context of the environmental protection era, the government can promote green innovation through institutional constraints [1]. The Chinese government has introduced policies to improve the quality of the environment and the efficiency of environmental protection, one of which is environmental information disclosure [2], which provides the stakeholder access to the corporate's environmental information and whether it helps promote green innovation deserves investigation.

Through distinctive studies, scholars have identified the factors that drive green innovation. Takalo et al. (2021) [3] provide a systematic review of the factors influencing green innovation at the macro level, including environmental policies; industry competition; digital economy development; and, at the micro level, including top management team characteristics, board structure, etc. Although governments influence green innovation considerably [4], the existing literature is less focused on the impact of environmental information disclosure on green innovation. Moreover, this study finds the inconsistency of previous studies on the relationship between environmental information disclosure and green innovation strategy. On the one hand, Li et al. (2022) [5] apply the difference in different methods for prefecture-level cities in China. The results indicate that environmental information disclosure is more likely to promote green technology innovation. Prior studies rely on data from an established market that has outperformed in terms of

global environmental performance. However, little is known about whether environmental information disclosure affects green innovation strategic decisions in other economies, especially in emerging economies such as China. Therefore, this study aims to demonstrate the relationship between environmental information disclosure and green innovation, explaining the “environmental information disclosure paradox”.

Further, few studies have examined the boundary conditions of the relationship between environmental information disclosure and green innovation. To fill these research gaps, this study identifies formal and informal institutional conditions that characterize the uniqueness of China. Based on institutional theory, North (1990) [6] points out that institutions are divided into formal and informal. Formal institutions include contracts, procedures, regulatory standards, and rules concerning a country’s governance and politics, while informal institutions comprise society’s social norms, values, and culture. On the one hand, the strategic behavior of firms and the performance of market functions depend on formal institutions; the role of formal institutions in reducing transaction costs through deregulation, such as market intermediaries that disseminate reliable information to protect property rights; and legal institutions that enforce contracts [7]. On the other hand, formal institutions are often missing in emerging economies such as China, a situation that Khanna and Palepu (1997) [8] define as an “institutional void”; thus, the informal institution plays an essential role as an alternative to the formal institution. The role of informal institutions in reducing uncertainty arise in the decision-making processes of all agents and individuals involved [9]. Political connections influence firms as informal institutions, and political connections are related to corporate goals and governmental interests in promoting specific public policy actions. This affects the enterprise’s ability to obtain resources, knowledge, and information from external sources [10], which impacts the corporate’s green innovation strategy. Thus, given the institutional environment and political connections as formal and informal mechanisms, exploring how they shape the effects of environmental information disclosure on green innovation strategy can contribute to a deeper understanding of the linkages between environmental information disclosure and corporate green innovation strategy.

Using a panel dataset of A-share listed firms in China from 2009 to 2021, this study investigates the impact of environmental information disclosure on green innovation and the moderating effect of formal (i.e., institution environmental) and informal (i.e., political connections) institutions on the above relationship. This study finds that environmental information disclosure positively impacts green innovation. The institution’s environment strengthens the relationship between environmental information disclosure and green innovation, but the political connection of executives weakened the above relationship. This study uses two-stage least square (2SLS) methods to reduce potential endogeneity issues.

This study contributes to the existing literature in several ways. First, this study provides a novel theoretical perspective to research the antecedents of green innovation. Prior research investigates the determinants of corporate green innovation from perspectives of industry competition and firm characteristics, such as corporate environmental inputs [11]. Moreover, while the prior literature has focused on traditional environmental regulatory measures, such as control and command-based and market-based tools, recent studies have shown the importance of using information tools [12]. Considering the critical role of information in strategic decision-making, environmental information disclosure provides a channel for stakeholders to understand corporate environmental information. However, little research has been paid to the impact of environmental information disclosure, an essential strategy for corporate green innovation. Thus, this study expands the empirical research on the determinants of corporate green innovation based on environmental information disclosure.

Second, this study enriches the boundary mechanisms by which environmental information disclosure affects green innovation. Although the prior literature has primarily focused on the boundary conditions between environmental information disclosure and green innovation, such as information transparency and corporate ownership [13], few

studies have analyzed how formal and informal institutions moderate the relationship between environmental information disclosure and green innovation. This study contributes to stakeholder theory research based on the importance of formal and informal institutions on the above relationship through stakeholder theory and institutional theory by constructing the integration of formal institutions (e.g., institutional environment) and informal institutions (e.g., political connections of decision-makers) into a theoretical model.

Third, corporate green innovation is significant for emerging economies like China. This study substantiates the positive effect of environmental information disclosure on corporate green innovation, providing an essential theoretical basis and references for the government to implement green innovation policies. This study complements prior studies by focusing on an emerging economy characterized by underdeveloped legal and financial systems, unique formal and informal institutions, growing environmental and ecological concerns, and employing a quantitative methodology based on a large sample.

2. Literature Review and Research Hypothesis

2.1. Literature Review

2.1.1. Green Innovation

Green innovation is technological innovation related to environmental protection and improvement. As a means of achieving sustainable development, green innovation is regarded as conducive to the win–win situation of economic growth and environmental protection. The prior literature examining green innovation influences is divided into internal and external aspects [3]. First, the external government environmental regulations and consumers' environmental protection awareness affect green innovation [14]. R&D tax incentivizes green innovation investment [15], and pollution emission taxation positively affects green innovation [16]. Meanwhile, with the increase in consumers' environmental awareness, consumers prefer green and energy-efficient products [17], and green innovation helps firms to produce green products to meet customers' requirements to protect the environment [18]. Environmentally friendly suppliers provide technical support to firms, which positively impacts the adoption and application of green innovation [19].

Second, there are internal influences of green innovation, such as authority assets and capabilities, green human resources, ecological management frameworks, and ethical culture [20]. Specifically, on the one hand, the firm's age, size, ownership, and executive background characteristics affect green innovation [21]. For example, larger firms imply higher resource and capability conditions and will need to take on higher social responsibility and stakeholder pressure. Thus, they need to use green innovation to build a competitive advantage. On the other hand, based on capability perspective literature. For example, the empirical results of scholars show that green dynamic capabilities, green practices, and green value co-creation enhance green innovation in SMEs [22]. Cui et al. (2020) [23] point out that a theoretical perspective is provided to understand the relationship between inter-organizational learning and green innovation, suggesting that the ability to integrate green knowledge is essential in achieving green innovation.

2.1.2. Environmental Information Disclosure

Environmental information disclosure refers to a series of behaviors in which market players disclose their environmental performance, environmental expenditures, and environmental income in business activities to the public through media reports, social responsibility reports, corporate annual reports, corporate websites, etc. Environmental information disclosure impacts the enterprise's interests and social environment, and the prior literature examining environmental information disclosure is divided into two aspects. First, there are influencing factors of environmental information disclosure, including external factors such as media environment, air quality, and government anti-corruption pressure [24–26], and internal factors such as executive characteristics, corporate governance structure, and nature of property rights [27]. Second, there is the strategic effect of

environmental information disclosure. Scholars focus on the impacts of environmental information disclosure on firm value, profitability, debt financing cost, firm risk, etc.

2.1.3. Theoretical Basis

The new institutional economics has developed because of its broad research scope, drawing heavily on the knowledge and methods of various cross-disciplines and generating many different branches after Coase; however, looking through the research vein of the new institutional economics, the study finds that it has formed a basic research paradigm, including the following aspects.

First is methodological individualism. Schumpeter first used this term in 1908, and Mises defined “methodological individualism” by arguing that all behavior is human; there can be no existence or reality of social groups when the behavior of individual members is excluded [22]. The new institutional economics treats the individual with preferences as the cornerstone of the theory, explaining economic, legal, and historical institutions from the point of view of individual behavior, but differing from the “individualism” based on the philosophy of individualism. The new institutional economists believe that the institutional environment influences the preferences of economic parties in reality and that the purposes and preferences of individuals are not a given premise of economic analysis but the object of analysis.

Second, institutions are endogenous, a behavioral constraint. If the public choice school of thought studies institutions or rules per se, the new institutional economics school of thought explores institutional arrangements, the study of behavior within institutions. “The guarantee of order may be endogenous or predicted by the prediction of specific external outcomes”. This statement suggests two broad extremes in which institutions can arise: evolutionary rationalism and judicial centrism. At the same time, proponents of the new institutional economics prefer the former, arguing that institutions evolve gradually in a continuous gaming process and eventually form a natural endogenous state [27]. As institutions are established, they will define the choice set of people’s behavior and act as a constraint on human behavior, which in turn determines transaction costs and production costs, thus determining whether it is profitable and feasible to engage in economic activities, interconnecting the past with the present and the future. Thus, institutional arrangements are part of economic behavior, while institutions constantly evolve and change.

North has already mentioned the role of ideology in institutional change. Ideology is seen as a factor that influences the “range of acceptable choices”, the “goals of people’s lives”, and the concept of “justice” and institutional orthodoxy. In particular, it is seen as a factor that can overcome the problem of free-riding and lead to forming groups that can exert political pressure. However, because North’s emphasis remains more on formal institutions and does not sort out the relationship between informal and formal institutions, “the focus on ideology has not been used to revise neoclassical state theory has not been integrated into the theoretical framework”. Instead, in institutions, institutional change, and economic performance, North formally merges informal rules into institutional analysis, arguing that it defines the choice set of human behavior along with formal rules and their implementation characteristics. “Mere changes in relative prices” are insufficient to explain the sources of institutional change; “ideas, ideologies, doctrines, and preferences are also important sources of institutional change”.

Third, it emphasizes that institutions are a key factor in economic growth and that the structure of property rights has a profound impact on economic performance. While traditional economic theory does acknowledge the existence of political, legal, monetary, and other institutions, the superficial assertion that these institutions either have little impact on economic performance or are exogenously given is unquestionable. In particular, the power structure, including property rights, constitutes the market, while the market influences it. The importance of institutions is that they are behavioral norms that determine people’s behavioral rights and space and, thus, behavioral choices and that different behavioral choices determine different resource allocation efficiencies.

The neoclassical research paradigm is still in the mainstream of economics, and the new institutional economics paradigm, which was once considered “heretical”, is now widely accepted, but the focus of research methods is different, and they will coexist in the long-term rational competition. Whether the new institutional economics research “paradigm” leads to the creation of a new “conventional science” is difficult to determine easily, but one thing is clear: this competitive process is an inevitable procedure for developing a science. It may be an exaggeration to consider the new institutional economics as a paradigm alternative to neoclassical economics, but the novel research paradigm established by the new institutional economics is enacting a scientific revolution.

2.1.4. Research Gap

From the literature review, although the prior literature has examined the drivers of green innovation from internal and external factors, the external factors consist of institutional pressures from the authorities and exclusive stakeholders, such as customers, suppliers, competitors, and NGOs [28]. Further, prior studies have supported that environmental information disclosure has a positive effect on reducing agency costs, financing constraints, and increasing firm value [29]. However, few scholars have investigated the theoretical mechanisms of the role of environmental information disclosure on green innovation, especially empirical studies on analyzing the moderating mechanism of formal and informal institutions. Thus, this study focuses on environmental information disclosure governance effects and investigates how it affects green innovation to enrich the existing literature.

2.2. Research Hypothesis

2.2.1. Environmental Information Disclosure and Green Innovation

The core view of stakeholder theory is that stakeholders have a critical influence on the survival and growth of the enterprise. Freeman et al. (2020) [30] point out that implementing strategic behaviors that meet stakeholders’ environmental needs helps the corporate improve its ethical and social responsibility. In addition, by disclosing environment-related information and thus sending positive signals to external stakeholders, the enterprise helps to acquire resource support for strategic development [31]. Environmental information disclosure reporting is essential for a company to disclose environmental information to external stakeholders. Thus, this study argues that the direct impact of environmental information disclosure on corporate green innovation can be explained based on stakeholder theories.

First, corporates with higher levels of environmental disclosure are more socially responsible and ethically committed, able to consider stakeholders’ interests, and expect to develop a sustainable relationship [32]. The quality of environmental information disclosure is one of the essential resources and capabilities that determine a firm’s competitive advantage [33]. As the CSRC implements environmental information disclosure policies, corporates’ enhancement of green innovation is an integral strategy to achieve environmental success [34]. In addition, green innovation is risky, uncertain, and external. Managers tend to focus on short-term returns and reduce green innovation out of self-interest, while more environmentally friendly stakeholders will enhance the monitoring of managers for the long-term benefit and motivate managers to make a corporate green innovation strategy.

Second, environmental information disclosure improves corporate information transparency [35], reducing information asymmetry between corporates and stakeholders, thus helping the corporate promote green innovation. For example, Lu et al. (2020) [36] point out that environmental information disclosure is a strategic choice for corporates to make an excellent impression on stakeholders and increase analysts’ attention, reducing information asymmetry between corporates and stakeholders. Environmental information disclosure provides environmental information about corporates, and corporations with high environmental performance are incentivized to disclose reliable environmental information to distinguish themselves from other enterprises [37]. This indicates that environmental

information disclosure increases valuable signals sent to stakeholders such as governments and banks. First, the government is one of the most important external stakeholders [38]. The CSRC implementation of environmental information disclosure policies increases the corporate legitimacy pressure, which cannot avoid government regulation by simply behaving strategically, but must take substantial measures to improve environmental performance, such as engaging in green innovation [34]. This helps emphasize firms' long-term commitment to environmental protection. Second, as major stakeholders, banks collect environmental information and monitor the accuracy of the information on corporate loan applications [39]. Banks can assess the loan terms of applicants through environmental information disclosures, making it more straightforward for corporates with more comprehensive and higher quality environmental information disclosure to obtain credit financing support [40]. When corporates face stringent lending scrutiny and high environmental access barriers, they can improve information transparency between corporates and banks through signaling effects to acquire loans, providing adequate financial support for green innovation. Thus, this study proposes the following hypothesis.

Hypothesis 1. *Environmental information disclosure is positively related to green innovation.*

2.2.2. Moderation Effect of Institutional Environment

Formal institutions are essential in promoting CSR behavior [41]. This reflects the development of efficient market functioning, which exhibits variation across regions in China. According to institutional theory, the institutional environment impacts organizations' structure and strategic behavior [42]. An efficient legal system, good government-market relations, and well-developed product and factor markets promote the flow of information, foster competition, and reduce externalities, making markets healthy [43]. The resources and conditions on which green innovation depends are the key variables. In contrast, access to core resources depends on market-based and non-market-based strategies determined by the institutional environment. Further, firms in transition economies face higher levels of external uncertainty, particularly regulatory uncertainty, than their counterparts in developed economies. It is crucial to consider the impact of institutional factors on their strategic development, investment and financing behavior, and strategic business decision-making [44]. The result of environmental information disclosure on corporate green innovation depends on the effect of institutional environment pressures, which can be classified as mandatory, imitative, and normative.

First, mandatory pressure is defined as "formal pressure generated by the institutions and regulations of the society to which the firm belongs". A developed institutional environment implies that Intellectual Property (IP) protection is effective, reducing transaction costs and the risks involved in green innovation, and that firms have stronger incentives for environmental information disclosure, driving them to apply for green patent applications rather than relying on contacts with bureaucratic or administrative authorities to deal with IP infringement [45]. Thus, a mature institutional environment is a reliable system for providing quantitative indicators of environmental information disclosure, enhancing the long-term orientation of decision-makers and contributing to environmental information disclosure promoting green innovation.

Second, imitative pressure is the pressure to imitate competitors' behavior, identified as success. A firm that adapts to imitation pressure is more likely to protect itself from potential losses and gain legitimacy. Thus, it imitates leading competitors to ensure social and decision legitimacy [46]. From this perspective, environmental information disclosure reflects an imitation of peer organizational behavior, thus providing external resources to support green innovation. For example, Li et al. (2020) [29] consider that environmental information disclosure is a new tool for environmental governance and that environmental information disclosure shows a significant spatial "club" distribution pattern with the "superposition effect" and the "peer effect" of mutual imitation and learning due to previous accumulation.

Third, normative pressure comes from the values and standards of behavior suggested and expected by external stakeholders [47]. Companies must comply with external stakeholders' standards, norms, and expectations to achieve legitimacy. In particular, stakeholders develop critical normative pressures, which become important drivers of corporate environmental information disclosure. For example, positive consumer perceptions of a firm's environmentally friendly products and socially responsible activities change the firm's environmental information disclosure intentions through normative pressures, which influence green innovation decisions.

On the one hand, in regions with a developed institutional environment, firms can be provided with the necessary property rights protection to safeguard the benefits of environmental information disclosure [48], enhance the long-term orientation of decision-makers, further enhance their motivation to engage in environmental information disclosure-driven green innovation, and effectively protect their green innovation outcomes. On the other hand, institutional pressure enhances environmental information disclosure's positive impact on a firm's reputation. The critical factors of green innovation capability depend on environmental information disclosure [49], which is consistent with the cognitive structure of entrepreneurs' knowledge and social legitimacy and contributes to the positive impact of environmental information disclosure on green innovation. Thus, this study proposes the following hypothesis.

Hypothesis 2. *The positive relationship between environmental information disclosure and corporate green innovation is strengthened when firms have an institutional environment (moderation effect of informal institutions).*

2.2.3. Moderation Effect of Political Connections

Political connections are embedded in the social context of trust in China and serve as a channel for information exchange between the government and corporates [50]. Prior scholars argue that an organization can be defined as a political connection if it has at least one executive who has held or is presently holding a prominent position in government. According to institutionalist perspectives on emerging economies, including China, corporates operating in such institutional environments rely on relationship-based mechanisms such as relational networks and political connections to make strategic decisions. Research has shown that political connection as an informal institution is perceived as a means for organizations to decrease uncertainty and share information about acceptable and effective corporate strategic practices [51]. Thus, social networks formed by executives' political connections may be an important moderating factor for the impact of environmental information disclosure on corporate green innovation decisions.

First, while political connections may constitute an essential means for firms to access important resources to support business activities in emerging economies, these connections may increase government intervention in their operations [52]. In particular, such interventions can force corporations to pursue political goals or desires incompatible with their market-driven objectives, for this reason exhibiting the negative consequences of political linkages [53]. Thus, allocating corporate attention to preserving political relationships with the authorities to meet the government's political goals can change the willingness to environmental information disclosure, hence minimizing the motivation for corporate's green innovation.

Second, this government intervention influences the firm's decision-making and efforts to develop relationships with external stakeholders. When a firm is highly politically connected, it may be more inclined to cultivate relationships with stakeholders by allocating its welfare-related resources through co-option mechanisms based on assigned political missions rather than competitive market considerations [54]. In other words, executives of firms with high political connections are likely to be overly concerned with achieving the assigned political mission, thereby potentially reducing the focus on environmental

information disclosure and weakening their sensitivity to pursuing other, more competitive strategies with higher value-added potential.

Third, because of the predominance of political considerations among executives, these firms may suffer from what Gargiulo and Benassi (2000) [55] create as over-embeddedness, which inhibits their creativity in exploring new strategic alternatives to build more financially viable relationships with key external stakeholders and other than officials. In addition, because politically connected firms often have government bureaucrats on their boards, it is questionable whether they have the expertise and professionalism needed to run their businesses [56]. The lack of competencies may affect the deployment of corporate resources, including environmental information disclosure strategy or how R&D expenditures are spent. The analysis suggests that political connections may discourage management's willingness to environmental information disclosure; reduce discretion and creativity in deploying green innovation expenditures in response to competitive market and resource conditions, i.e., reduce willingness to environmental information disclosure; and crowd out R&D expenditures, ultimately to the detriment of enhancing green innovation. The following hypotheses are proposed. In summation, the theoretical model of this study is shown in Figure 1.

Hypothesis 3. *The positive relationship between environmental information disclosure and corporate green innovation is weakened when firms have political connections (moderation effect of informal institutions).*

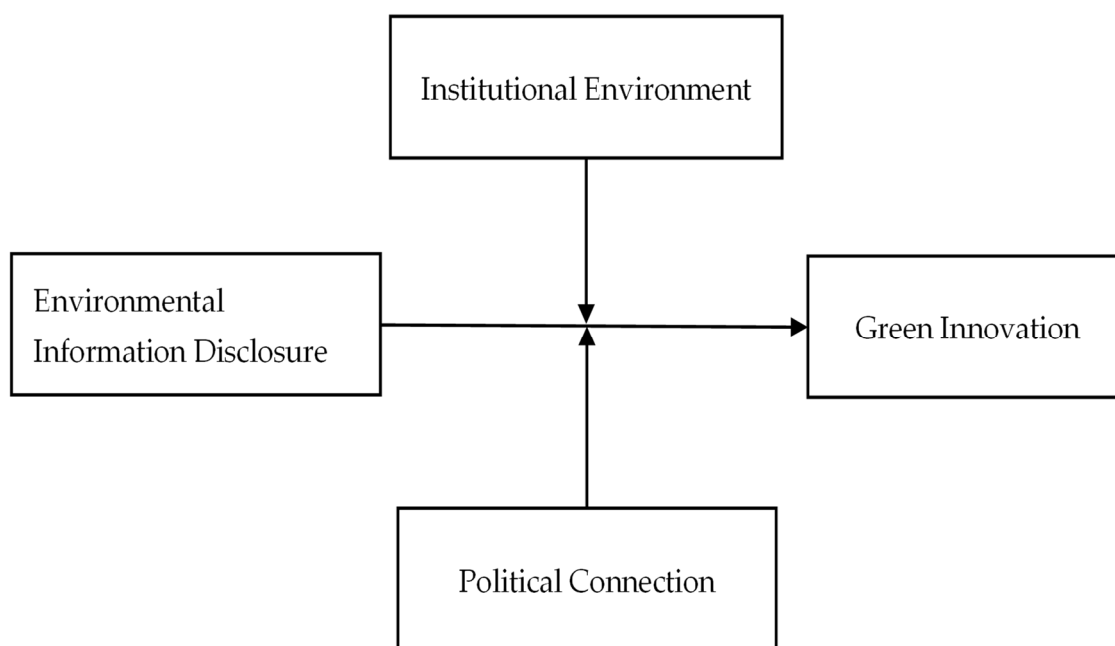


Figure 1. Theoretical research model.

3. Data and Methodology

3.1. Data and Samples

This study selects the data of Chinese A-share listed companies from 2009 to 2021 as the sample. The sample period starts from 2009 because the Shanghai Stock Exchange issued the guidelines on environmental information disclosure of listed companies in 2008, which marks the beginning of the gradual disclosure of environmental information by Chinese companies. The green patent data is obtained by comparing the patent classification number information of all A-share listed companies from the State Intellectual Property Office (SIPO) with the “IPC Green List” published by the World Intellectual Property Organization (WIPO). The firm-level data such as environmental information disclosure, governance structure, and financial data were obtained from the China Stock Market

and Accounting Research (CSMAR) Database (<http://www.gtarsc.com>), which provides comprehensive historical information on the financial statements and corporate governance in the Shanghai and Shenzhen Stock Exchanges [57]. The data for the marketization index are collected from the Wind database. The Wind database (www.wind.com.cn) provides accurate and real-time data on Chinese firms, industries, and the financial market. The data collected from the Wind database are used in research reports and academic studies.

This study sample has the following exclusions: (1) special treatment (ST) and particular transfer (PT) since these firms had experienced unusual financial performance; (2) debt to total assets ratio greater than 1; (3) missing variable data. In addition, all continuous variables are winsorized at the first and 99th percentiles. Ultimately, this study obtained the panel data with 18,394 firm-year observations.

3.2. Variables Definition

3.2.1. Dependent Variable

Green Innovation (GRInno). Referring to the existing literature [3,58], the dependent variable is the number of green patent applications of listed companies. Since each patent application has a corresponding International Patent Classification number, patents can be classified into detailed technical subcategories. Thus, combining the list of green technologies issued by the WIPO, this study uses the classification code of each patent to identify and count the total number of green patents. The indicators of the number of green patent applications include the total number of green patents. The number of green patents applied by listed companies is logarithmically processed.

3.2.2. Independent Variable

Environmental Information Disclosure (EID). The quality of environmental information disclosure is measured by the content of environmental disclosure [59]. Since 2008, the Chinese Shanghai Stock Exchange guidelines have required listed companies to disclose whether they cause pollution, what environmental protection measures they have taken, and their environmental protection inputs and costs. Referring to these guidelines and following the prior literature [59,60], this study uses a content analysis approach to collect information from sustainability reports, social responsibility reports, annual reports of listed companies, and environmental reports to an indicator constructed to measure the quality of environmental information disclosure.

According to the requirements of the Shanghai Stock Exchange guidelines, the environmental information disclosed is divided into seven content components: environmental management, government regulation, agency certification, environmental costs, environmental liabilities, environmental inputs, and environmental liabilities. Each section also includes different sub-indicators, with a total of twenty-nine sub-indicators. This study summarizes the annual scores of the sum of each firm's seven components, constructs a raw index of environmental information disclosure quality, and further standardizes the basic index by dividing the raw index by the maximum possible score to obtain a measure of environmental information disclosure quality.

3.2.3. Moderation Variables

Marketization index (MI). According to the research of Li and Ramanathan (2020) [61], the existing studies use the score of the marketization index to represent the formal institutional environment, especially in the Chinese research setting. The marketization index can systematically assess the institutional environment of each province in mainland China. The newest version of the marketization index was released in 2019, and the periods cover from 2008 to 2016 [62]. The marketization index appraises the institutional environment of each province. To better reflect the institutional environment of each province, following the common practice of existing studies, this study employs the total marketization index of each province to capture the institutional environment. Regions of the province with higher scores on the marketization index mean that their institutional environment is better.

The missing data of the marketization index from 2017 to 2021 have been supplemented by the interpolation method.

Political connections (PC). According to the research of Song et al. (2015) [63], based on the characteristics of equity structure and the actual controllers of China's listed companies, this study defines a "political connection" as that belonging to the actual controller or chairman of an enterprise (i.e., a present or former government official, an NPC member, or a CPPCC member). When this condition exists, an enterprise can be defined as "politically connected". The final controllers or chairpersons were identified by reviewing the annual reports of listed companies and the resumes of the final controllers or chairs.

3.2.4. Control Variables

This study includes a series of control variables to control for the effects of corporate characteristics, financial status, and governance structure. This study contains the firm size (Size), firm age (Age), board size (Board), whether the chairman of the board and CEO are the same person (Duality), the proportion of independent directors (Inde), the largest shareholder (Holder1), asset–liability ratio (Lev), ROA, asset-fixed asset ratio (Tangibility), Growth, and Soe while controlling the fixed effects of year and industry. Each variable is defined and measured, as shown in Table 1.

Table 1. Variable definitions.

Variables		Description
Dependent Variable	GRInno	The indicators of the number of green patent applications include the total number of green patents.
Independent Variable	EID	This study summarizes the annual scores of the sum of each firm's seven components, constructs a raw index of environmental information disclosure quality, and further standardizes the basic index by dividing the raw index by the maximum possible score to obtain a measure of environmental information disclosure quality.
Moderation Variables	MI	This study uses the score of the marketization index, especially in the Chinese research setting. The marketization index can assess the institutional environment of each province in mainland China systematically.
	PC	This study uses an enterprise's actual controller or chairman (i.e., a present or former government official, an NPC member, or a CPPCC member). When this condition exists, an enterprise can be defined as "politically connected".
Control Variables	Size	The natural logarithm of total assets
	Age	The number of years that the firm has been established
	Board	The number of the corporate board of directors for the year
	Duality	If the chairman and the CEO are same people, the value is 1, and the opposite is 0
	Inde	The number of independent directors/total number of board members
	Holder1	Percentage of shares held by the largest shareholder
	Lev	The total liabilities of the enterprise are compared with the total assets
	ROA	Net profit divided by average total assets
	Tangibility	The total fixed assets of the enterprise are compared with the total assets
	Growth	The ratio of the difference between the current period's operating income minus the previous period's operating income divided by the prior period's operating income
	Soe	The value is taken as 1 when the enterprise is a state-owned enterprise, and as 0 otherwise

3.3. Models

This study uses a fixed-effect (FE) regression model similar to the one used in prior green innovation studies [64]. Moreover, green innovation variables in the subsequent year were considered to address the reverse causality issue. Thus, this study tests the effect of environmental information disclosure on corporate green innovation and specifies the following panel data with the FE regression model:

$$GRInno_{i,t+1} = \alpha_0 + \alpha_1 EID_{i,t} + \alpha_k \sum Control_{it} + \sum Ind + \sum Year + \varepsilon_{i,t} \quad (1)$$

$$GRInno_{i,t+1} = \beta_0 + \beta_1 EID_{i,t} + \beta_2 MI_{i,t} + \beta_3 EID_{i,t} \times MI_{i,t} + \beta_4 PC_{i,t} + \beta_5 EID_{i,t} \times PC_{i,t} + \beta_k \sum Control_{i,t} + \sum Ind + \sum Year + \varepsilon_{i,t} \quad (2)$$

In Equation (2), β_1 refers to the coefficient of the independent variable (i.e., digital transformation). β_2 and β_4 represent the coefficients of two moderators (i.e., marketization index and political connections). β_3 and β_5 denote the coefficients of two interactions with the dependent variable. β_k represents the coefficients of a series of control variables. $\sum Ind$ and $\sum Year$ represent industry and year dummy variables. ε_{it} is the random error term. This study means to center all continuous variables when calculating the interaction terms.

4. Empirical Findings

4.1. Descriptive Statistics and Correlation Analysis

Table 2 reports the descriptive statistics of the variables of empirical analysis. The total number of green patent applications (GRInno) was 0.383, with a standard deviation of 0.778, indicating a large variation in the level of green patent applications among listed companies. The mean value of environmental information disclosure was 0.078, indicating a low average level of environmental information disclosure. In addition, Table 2 also reports the results of the Pearson correlation analysis. The environmental information disclosure positively correlates with green innovation, which provides preliminary support for H1. In addition, the correlation coefficients for independent and control variables were less than 0.5. The variance inflation factor (VIF) was less than 2, thus indicating that multicollinearity was not a concern, and the mean values of green patent applications and environmental information disclosure have changed over time, as shown in Figure 2.

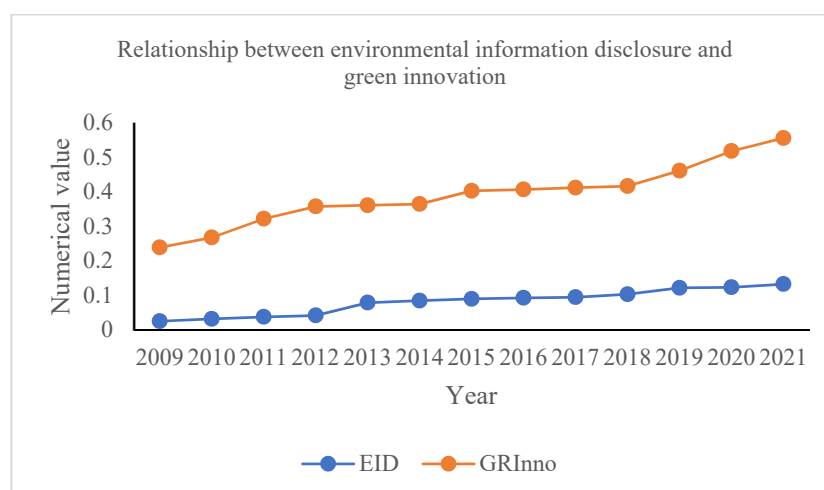


Figure 2. Relationship between environmental information disclosure and green innovation.

Table 2. Descriptive statistics and correlation analysis.

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. GRInno	0.383	0.778	1														
2. EID	0.078	0.162	0.102 c	1													
3. MI	9.244	3.253	0.078 c	−0.049 c	1												
4. PC	0.234	0.423	0.010	0.000	−0.026 c	1											
5. Size	22.022	1.267	0.243 c	0.247 c	0.047 c	−0.003	1										
6. age	2.863	0.340	−0.043 c	0.080 c	0.234 c	−0.078 c	0.166 c	1									
7. Board	2.258	0.175	0.063 c	0.108 c	−0.135 c	−0.008	0.283 c	−0.002	1								
8. Dualiy	0.259	0.438	−0.007	−0.065 c	0.121 c	0.000	−0.208 c	−0.074 c	−0.185 c	1							
9. Inde	0.372	0.053	0.026 c	−0.029 c	0.037 c	0.017 b	0.014 b	−0.0110	−0.504 c	0.094 c	1						
10. Holder1	0.376	0.150	0.043 c	0.043 c	0.022 c	0.003	0.147 c	−0.176 c	−0.00700	−0.01	0.055 c	1					
11. Lev	0.416	0.208	0.101 c	0.091 c	−0.110 c	−0.073 c	0.487 c	0.154 c	0.177 c	−0.171 c	−0.018 b	−0.055 c	1				
12. Roa	0.040	0.060	0.022 c	−0.011	0.047 c	0.049 c	−0.016 b	−0.090 c	−0.00400	0.062 c	−0.013 a	0.174 c	−0.382 c	1			
13. Tangibility	0.248	0.164	−0.032 c	0.268 c	−0.140 c	−0.019 c	0.193 c	0.044 c	0.153 c	−0.113 c	−0.038 c	0.028 c	0.177 c	−0.135 c	1		
14. Growth	0.206	0.399	0.008	−0.092 c	−0.025 c	0.039 c	−0.102 c	−0.238 c	−0.050 c	0.134 c	0.006	0.059 c	−0.176 c	0.237 c	−0.243 c	1	
15. Soe	0.404	0.491	0.032 c	0.118 c	−0.181 c	−0.090 c	0.398 c	0.150 c	0.295 c	−0.316 c	−0.062 c	0.099 c	0.336 c	−0.126 c	0.235 c	−0.192 c	1

Notes: This table presents the Pearson correlations among the main variables in this study. All the variables are defined in Table 2. a, b, and c indicate statistical significance at the 10%, 5%, and 1% levels, respectively, using a two-tailed *t*-test.

4.2. Multiple Regression Analysis

4.2.1. The Effect of Environmental Information Disclosure on Green Innovation

Table 3 reports the results of baseline regressions. Considering the reliability of the research results, the regression models are based on the fixed effect, and the control variables are included in all regression models. The results show that in column (1), the coefficient of the environmental information disclosure variable is 0.287, which is significantly positive at the level of 1%, indicating that environmental information disclosure has significantly improved the green innovation of enterprises. The (2) column controls the year and industry fixed effects, and the coefficient of environmental information disclosure is 0.138, which is significantly positive at the level of 5%, indicating that environmental information disclosure has increased the number of green patents. Thus, H1 is supported. This finding indicates that firms with environmental information disclosure tend to be more inclined to pursue sustainability policies and thus improve sustainability performance. Theoretically, the findings of this study are consistent with the prediction of stakeholder theory that disclosures from environmental information are subject to legitimacy pressure from stakeholders, help firms obtain resource support for strategic development, and have an impact on achieving effective implementation of institution-driven sustainability regulations and policies [30]. Prior studies have found similar findings when examining the impact of environmental information disclosure on the social responsibility performance of Chinese listed companies [34].

Table 3. The regression results of environmental information disclosure on green innovation.

Variables	(1) GRInno	(2) GRInno
EID	0.287 *** (7.648)	0.138 *** (3.473)
Size	0.046 *** (4.296)	0.044 *** (3.922)
Age	0.228 *** (7.226)	0.060 (0.771)
Board	0.084 * (1.717)	0.089 * (1.821)
Dualiy	−0.019 (−1.381)	−0.024 * (−1.762)
Inde	0.232 * (1.774)	0.218 * (1.674)
Holder1	−0.118 * (−1.941)	−0.149 ** (−2.416)
Lev	0.009 (0.217)	0.029 (0.684)
Roa	0.081 (0.948)	0.107 (1.247)
Tangiblity	−0.034 (−0.682)	−0.036 (−0.725)
Growth	−0.034 *** (−3.059)	−0.028 ** (−2.502)
SOE	−0.043 (−1.399)	−0.023 (−0.741)
Consatnt	−1.515 *** (−6.551)	−0.983 *** (−2.862)
Firm FE	Yes	Yes
Industry FE	No	Yes
Year FE	No	Yes
N	18,394	18,394
Adj.R2	0.6491	0.6524

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.2.2. Moderation Effect Test

Table 4 reports the moderation effect of institutional environment and political connections on the relationship between environmental information disclosure and green innovation. H2 was tested in column (1), which predicts that the interaction between institutional environment and environmental information disclosure moderates environmental information disclosure on green innovation. Since the interaction term between institutional environment and environmental information disclosure has a significantly positive effect on green innovation ($\beta = 0.126$, $t = 2.262$), the results of model 2 support the prediction of H2. The positive effect of environmental information disclosure on green innovation is strengthened in the more advanced regional institutional environment. In addition, H3 was tested in column (2), which predicts the effect of the interaction between political connections and the presence of environmental information disclosure on green innovation. Given that model 3 shows that the interaction term between political connections and environmental information disclosure has a significant negative effect on green innovation ($\beta = -0.134$, $t = -1.961$), the empirical results support H3, indicating that political connections weaken the positive effect of environmental information disclosure on green innovation.

Table 4. The moderating effect results of institutional environment and political connections.

Variables	(1) GRInno	(2) GRInno	(3) GRInno
EID	0.146 *** (3.670)	0.168 *** (3.938)	0.177 *** (4.130)
MI	0.018 (1.496)		0.019 (1.500)
EID \times MI	0.126 ** (2.262)		0.127 ** (2.271)
PC		−0.006 (−0.437)	−0.006 (−0.399)
EID \times PC		−0.134 ** (−1.961)	−0.136 ** (−1.987)
Size	0.045 *** (3.973)	0.045 *** (3.980)	0.045 *** (4.029)
Age	0.059 (0.765)	0.061 (0.796)	0.061 (0.791)
Board	0.088 * (1.807)	0.089 * (1.819)	0.088 * (1.805)
Dualiy	−0.025 * (−1.797)	−0.024 * (−1.793)	−0.025 * (−1.826)
Inde	0.219 * (1.682)	0.220 * (1.683)	0.221 * (1.691)
Holder1	−0.149 ** (−2.418)	−0.150 ** (−2.430)	−0.150 ** (−2.433)
Lev	0.030 (0.709)	0.029 (0.676)	0.030 (0.704)
Roa	0.101 (1.173)	0.107 (1.247)	0.101 (1.173)
Tangiblity	−0.037 (−0.726)	−0.038 (−0.760)	−0.038 (−0.763)
Growth	−0.028 ** (−2.517)	−0.029 ** (−2.546)	−0.029 ** (−2.563)
SOE	−0.023 (−0.740)	−0.023 (−0.744)	−0.023 (−0.743)
Consatnt	−0.982 *** (−2.862)	−0.994 *** (−2.893)	−1.002 *** (−2.918)
Firm FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	18,394	18,394	18,394
Adj.R2	0.6523	0.6522	0.6523

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

This result indicates that institutional environment and political connections are essential boundary conditions for the study. On the one hand, the new institutional economics argues that institutions are a crucial factor in economic growth and that the structure of property rights profoundly affects performance. Institutions are important because they are behavioral norms that determine people's behavioral rights and space, which determine behavioral choices. Different behavioral options determine different resource allocation efficiencies. Therefore, in regions with a developed institutional environment, firms can be provided with the necessary property rights protection to safeguard the interests of environmental disclosure [48] and effectively protect their green innovation outcomes. On the other hand, North formally incorporated informal rules into institutional analysis, arguing that it defines the choice set of human behavior along with formal rules and their implementation characteristics. Political connection, as a representative of informal institutions, is found to have effects that crowd out the positive effects of environmental disclosure, which may discourage management's willingness to disclose environmental information, reduce discretion to deploy green innovation expenditures in response to competitive market and resource conditions, and ultimately discourage the enhancement of green innovation [52].

4.2.3. Endogeneity Test

Table 5 reports the results of the 2SLS regression method. Considering that firms with a higher level of green innovation are driven to achieve environmental information disclosure, this study proposes to use an instrumental variable with a two-stage least squares method for mitigation. To eliminate the bias of the estimated coefficients due to potential endogeneity, referring to the research of instrumental variables [65], this study constructs a share shift method instrumental variable (Bartik), which is the product of the average value of industry-level environmental information disclosure (share) and the growth rate of all environmental information disclosure levels (shift) in the lagged period except for firms. The product of share and shift is used as the instrumental variable of environmental information disclosure. The view is that the initial share composition of the unit of analysis and the overall growth rate is used to simulate the estimates over the years, and the construction of the shift-share can alleviate the lack of exogeneity of the traditional industry-level instrumental variables,

Table 5. 2SLS regression method result.

Variables	First Stage	Second Stage	
	(1) EID	(2) GRInno	(3) GRInno
EID		0.580 *** (2.612)	0.529 ** (2.252)
IV_Bartik	7.653 *** (24.581)		
Size	−0.084 *** (−4.331)	0.031 ** (2.236)	0.032 ** (2.129)
Age	0.227 *** (3.807)	0.234 *** (5.525)	0.107 (1.066)
Board	−0.078 (−0.617)	0.077 (1.273)	0.086 (1.418)
Duality	−0.014 (−0.390)	−0.024 (−1.400)	−0.028 * (−1.646)
Inde	−0.237 (−0.664)	0.088 (0.551)	0.090 (0.565)
Holder1	−0.232 * (−1.931)	−0.111 (−1.493)	−0.133 * (−1.749)
Lev	0.321 *** (3.010)	−0.029 (−0.538)	−0.005 (−0.088)

Table 5. Cont.

Variables	First Stage	Second Stage	
	(1) EID	(2) GRInno	(3) GRInno
Roa	0.560 * (1.807)	0.080 (0.748)	0.103 (0.950)
Tangibility	1.185 *** (9.636)	−0.091 (−1.446)	−0.092 (−1.443)
Growth	−0.043 (−0.662)	−0.025 (−1.254)	−0.019 (−0.957)
SOE	−0.043 (−1.060)	−0.069 * (−1.821)	−0.057 (−1.480)
Firm FE	Yes	Yes	Yes
Industry FE	Yes	No	Yes
Year FE	Yes	No	Yes
N	13,291	13,291	13,291
Adj.R2	0.4610	0.0162	0.0186
Kleibergen–Paap rk LM statistic		131.388 ***	
Cragg–Donald Wald F statistic		463.259 [16.38]	

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The first-stage regression results show that the instrumental variable IV_Bartik has good explanatory power for the endogenous variable environmental information disclosure and satisfies the correlation requirement of the instrumental variable. The Kleibergen–Paap rk LM statistic is positive at the 1% significance level, rejecting the hypothesis of cognitive deficiency. The Cragg–Donald Wald F statistic is greater than the Stock–Yogo weak instrumental variable at the 10% significance level. The critical value of the identification F test and the weak identification hypothesis is rejected. In conclusion, the instrumental variables are reliable. The results indicate that the effect of environmental information disclosure on green innovation is positive after addressing the endogenous problem, indicating the robustness of the research results.

4.2.4. Robustness Test

First, replace the variable measurement of green innovation. This study uses the logarithm of the number of authorized green patents plus one to remeasure green innovation. The regression results are shown in Table 6, from which it can be seen that the regression coefficient of environmental information disclosure is significantly positive after changing the green innovation measure, and the results are not significantly different from the prior regression results, indicating that the results of this study are robust.

Table 6. Robustness test of the variable measurement of green innovation.

Variables	(1)	(2)	(3)
	Authorized GRInno	Authorized GRInno	Authorized GRInno
EID	0.075 ** (2.327)	0.090 *** (2.599)	0.097 *** (2.785)
MI	0.011 (1.111)		0.011 (1.115)
EID × MI	0.101 ** (2.220)		0.101 ** (2.224)
PC		−0.008 (−0.693)	−0.008 (−0.657)

Table 6. Cont.

Variables	(1) Authorized GRInno	(2) Authorized GRInno	(3) Authorized GRInno
EID × PC		−0.095 *	−0.096 *
		(−1.714)	(−1.738)
Size	0.031 ***	0.031 ***	0.032 ***
	(3.427)	(3.442)	(3.493)
Age	0.108 *	0.110 *	0.109 *
	(1.725)	(1.756)	(1.746)
Board	0.052	0.053	0.052
	(1.322)	(1.332)	(1.322)
Duality	−0.018	−0.018	−0.018 *
	(−1.606)	(−1.614)	(−1.647)
Inde	0.126	0.127	0.127
	(1.195)	(1.199)	(1.205)
Holder1	−0.035	−0.035	−0.035
	(−0.701)	(−0.701)	(−0.707)
Lev	0.033	0.032	0.033
	(0.958)	(0.911)	(0.941)
Roa	0.119 *	0.124 *	0.119 *
	(1.705)	(1.774)	(1.706)
Tangibility	−0.046	−0.046	−0.047
	(−1.116)	(−1.136)	(−1.143)
Growth	−0.024 ***	−0.024 ***	−0.025 ***
	(−2.680)	(−2.696)	(−2.717)
SOE	−0.003	−0.003	−0.003
	(−0.123)	(−0.134)	(−0.130)
Constant	−0.895 ***	−0.906 ***	−0.913 ***
	(−3.217)	(−3.252)	(−3.277)
Firm FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	18,394	18,394	18,394
Adj.R2	0.6214	0.6213	0.6214

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Second, replace the regression standard error. This study refers to existing research methods and uses the estimation of Driscoll–Kraay standard errors [66], and the results are shown in Table 7. The study finds that after replacing the regression standard error calculation, the hypotheses results are robust.

Table 7. Robustness test of the replacement of the standard error of the regression.

Variables	(1) GRInno	(2) GRInno	(3) GRInno
EID	0.146 ***	0.168 ***	0.177 ***
	(3.436)	(3.368)	(3.343)
MI	0.018 **		0.019 **
	(2.308)		(2.288)
EID × MI	0.126 *		0.127 **
	(2.200)		(2.237)
PC		−0.006	−0.006
		(−0.424)	(−0.385)
EID × PC		−0.134 *	−0.136 *
		(−2.138)	(−2.115)

Table 7. Cont.

Variables	(1) GRInno	(2) GRInno	(3) GRInno
Size	0.045 *** (7.495)	0.045 *** (7.265)	0.045 *** (7.389)
Age	0.059 (1.425)	0.061 (1.419)	0.061 (1.458)
Board	0.088 * (1.825)	0.089 * (1.852)	0.088 * (1.818)
Duality	−0.025 * (−2.129)	−0.024 * (−2.134)	−0.025 * (−2.155)
Inde	0.219 (1.262)	0.220 (1.267)	0.221 (1.260)
Holder1	−0.149 * (−1.934)	−0.150 * (−1.931)	−0.150 * (−1.914)
Lev	0.030 (0.600)	0.029 (0.556)	0.030 (0.590)
Roa	0.101 (1.219)	0.107 (1.338)	0.101 (1.214)
Tangibility	−0.037 (−0.898)	−0.038 (−0.957)	−0.038 (−0.968)
Growth	−0.028 *** (−4.149)	−0.029 *** (−4.065)	−0.029 *** (−4.153)
SOE	−0.023 (−0.446)	−0.023 (−0.441)	−0.023 (−0.447)
Constant	−0.922 ** (−2.982)	−0.939 ** (−2.944)	−0.937 ** (−2.943)
Firm FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	18,394	18,394	18,394
Adj.R2	0.0390	0.0388	0.0393

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5. Conclusions and Discussion

As an emerging economy, China regards environmental protection as a national priority and considers green innovation a critical factor in achieving environmental sustainability. In the environmental accounting literature, there is a dispute on whether environmental information disclosure benefits a corporate strategy. Given the specificity of China as an emerging economy, this study investigates the impact of environmental information disclosure on corporate green innovation, the moderating effect of the institutional environment as a formal institution, and the political connections as an informal institution on these relationships. Based on the sample data of Chinese A-share listed companies, the empirical results show that environmental information disclosure enhances green innovation, identifying an essential driver of green innovation. Further tests show that the institutional environment strengthens the positive relationship between environmental information disclosure and corporate green innovation. However, the political connections weaken the positive effect of environmental information disclosure on green innovation. This study provides evidence to support the facilitative effect of environmental information disclosure on green innovation.

6. Theoretical Contribution

These findings provide the following theoretical contributions. First, this study enriches the green innovation literature by responding to the growing demand for new perspectives on green innovation in the era of environmental protection. Prior research has focused on the effects of institutional pressures [67], firm capabilities and strategies,

inter-firm relationships, and top management team characteristics [68] on green innovation. Although green innovation plays a crucial role in shaping corporate strategy in emerging economies [69], few studies have investigated how environmental information disclosure affects green innovation. Based on stakeholder theory, the results of this study point out that environmental information disclosure is a crucial antecedent when meeting stakeholders' needs. Further, the studies related to disclosure differ from the prior research, which argues that environmental information negatively impacts corporate strategy [70–72]. This finding helps to break through the “paradox” of environmental information disclosure and supports the shift in strategic resources from traditional internal corporate perspectives to external stakeholder research.

Second, this study develops stakeholder theory by discussing the importance of distinguishing between formal and informal institutions. The core view of stakeholder theory is that organizations should balance the interest requirements of various stakeholders in an integrated manner rather than focusing on accumulating shareholder wealth [73]. Including stakeholders in organizational decision-making can help enhance the competitive advantage. However, the role of institutional elements in setting strategic agendas has received little attention from stakeholder research [74]. Freeman et al. (2020) [30] point out that integrating stakeholder theory and complementary perspectives in institutional theory requires additional research. This study in formal and informal institutions is described in institutional theory into the integrated model to explain the boundary conditions for corporates' green innovation. Prior studies have focused on one aspect of stakeholders, such as ethical requirements and strategic resources [75]. Thus, this study attempts to integrate stakeholder theory and institutional theory to clarify how institutional elements shape environmental information disclosure and corporate green innovation, deepening our understanding of the role of stakeholder theory in green innovation.

Further, the prior literature has tended to emphasize that political connections can be an alternative to formal institutions in the absence of formal institutions, focusing more on its positive effects on firms' property rights protection, resource access, performance, and growth, and only in recent years on its negative effects [76]. Yet, the existing literature has rarely compared the differences between its role and that of formal institutions. The study links the two institutional factors mentioned above to firms' strategic decisions and finds that political connections exhibit the opposite effect of formal institutions. These results imply that political connections can become private political capital without a supportive monitoring system. Entrepreneurs can be tempted to use political connections for rent-seeking and deviate from the long-term strategic direction [77]. This study highlights the essential difference between informal and formal systems. It reveals how political connections have a negative effect as the primary motivation for political connections in China. Other East Asian countries are not related to corporate goals. Still, to governmental interests in promoting public policy actions [78]—thus weakening policymakers' initial long-term strategic orientation—this negative effect leads firms to devote fewer resources to green innovation activities through political connections.

7. Practical Recommendation

The results of this study have essential recommendations for environmental management in China and other emerging economies. First, the government should implement innovation-driven development strategies in response to insufficient innovation momentum and environmental pollution in emerging economy countries. The government, as a policy maker, encourages enterprises to enhance environmental information disclosure, and should further improve the availability of transparent environmental information to encourage enterprises to implement green development strategies, improve their green innovation capabilities, and better utilize such information to promote green innovation and achieve unity of economic and environmental benefits.

Second, enterprises should realize that the impact of environmental information disclosure on green innovation depends on the elements of the institutional environment.

The positive impact of environmental information disclosure on green innovation is more prominent in regions with the perfect institutional environment, and enterprises should comply with environmental regulations and pay attention to stakeholders' expectations on environmental protection. Countries with emerging economies encourage enterprises to participate proactively in environmental governance by moderately strengthening environmental regulations and intellectual property protection.

Third, a reasonable assessment mechanism should be established to make the process transparent and prevent some enterprises from siphoning off subsidy resources through politically connected rent-seeking behavior. Enterprises should also weigh the benefits and costs of political connections and make scientific green innovation decisions.

8. Limitations and Future Research

This study provides a new theoretical framework for green innovation by emphasizing the importance of environmental information disclosure and the boundary condition of formal and informal institutional characteristics. However, there are still some limitations in our research. First, this study uses stakeholder and institutional theories to explore the relationship between environmental information disclosure and green innovation. Future scholars may consider combining other relevant theories from sociology, psychology, and other disciplines essential for exploring the impact of environmental information disclosure on green innovation. Second, this study considers formal and informal institutional factors (i.e., institutional environment and political connection). Regarding future research directions regarding moderating mechanisms, other factors include institutional fragility, government quality, political capital, and pollution intensity. These factors can be moderating variables for environmental information disclosure and green innovation and can be further investigated in the future. Third, due to the lack of pollutant emission data of listed firms, it could not be observed whether the information program acts positively on the pollution behavior of firms, which might serve as an essential complement to green innovation. In addition, this study concentrated on China's listed firms, the scale of which is usually large. Thus, the findings cannot simply be applied to small and medium-sized firms. One possible future research direction is to explore how environmental information disclosure by the government affects the green innovation performance of small and medium-sized firms based on more comprehensive data.

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