



Article The Impact Mechanism of Environmental Information Disclosure on Corporate Sustainability Performance—Micro-Evidence from China

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Abstract: As an effective regulatory tool, environmental information disclosure is significant in promoting the green upgrading of industrial structures and achieving green transformation of enterprises. In order to explore the impact mechanism of environmental information disclosure on corporate sustainability performance, this paper constructs a two-way fixed-effect model using balanced panel data of Chinese A-share listed manufacturing companies from 2015 to 2020. We find that environmental information disclosure significantly impacts green innovation, thereby improving corporate sustainability performance. Furthermore, financing constraints inhibit the impact of environmental disclosure on sustainability performance, while female directors have only symbolic effect. The reliability of the paper's findings is verified by replacing the dependent variable and introducing instrumental variables. Heterogeneity analysis shows that the effect of environmental information disclosure on corporate sustainability performance is more substantial among non-state and eastern and heavily polluting enterprises. Comprehensive analysis from the financing perspective shows the differences in the moderating effects of debt and equity financing regarding the impact mechanism. This study enriches the theory of green innovation and provides financing strategies for enterprises to achieve green transformation, as well as suggestions for improving the government environmental information disclosure system.

Keywords: environmental information disclosure; green innovation; corporate sustainability performance; financing constraints; moderation mediating effect

1. Introduction

Developing countries have been practicing the 'development before governance' model of economic development for a long time. Although significant achievements have been made in industrialisation, urbanisation and informatisation, people have pursued high-speed economic development in a one-sided manner, leading to severe pollution of the ecological environment. Climate governance has become a significant challenge for countries, societies, and businesses. Therefore, in the context of the urgent economic recovery in the post-epidemic era, it has become a global consensus to deepen international cooperation to actively promote green and sustainable development. China is in a crucial period of economic transformation, and green development is the most effective way for the Chinese government to achieve 'peak carbon' and 'carbon neutrality'.



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Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https:// creativecommons.org/licenses/by/ 4.0/). Whether the concept of green and low-carbon development can be translated into policy dividends to promote a comprehensive green transformation of socioeconomic development depends on government macro-control and the response strategies of market players. From the macroeconomics perspective, government environmental information disclosure is an essential tool to promote environmental supervision and law enforcement and a crucial policy tool to improve environmental governance [1]. Environmental information proactively disclosed by the government or companies can turn public environmental awareness into a beneficial catalyst, effectively motivating the public to participate in environmental governance activities [2]. High-quality environmental information disclosure not only significantly improves the efficiency of urban green economies and objectively reflects local environmental performance [3] but also contributes markedly to local economic sustainability.

From the perspective of internal management and long-term development, companies should focus on the growth of financial indicators and actively undertake their ecological obligations and social responsibilities to improve their environmental performance. Highquality environmental information disclosure is not only an effective way for enterprises to fulfil their environmental responsibilities and promote green development but also a vital governance mechanism to reduce the degree of information asymmetry between corporate management and shareholders and alleviate agency conflicts [4]. Under the multiple supervision of the government, media, and the public, environmental information disclosure has become an effective instrument to promote corporate environmental governance and strengthen external regulation, which has a positive effect on adding value to enterprises and promoting their sustainable development [5,6]. Hardcopf et al. [7] propose opposite findings based on signalling theory. When an environmental accident or sudden event is disclosed, increased financial costs and reputation damage affect enterprises' short-term financial performance and environmental activities. Environmental information disclosure is a typical method of informal environmental regulation involving third parties, and environmental investment has a 'crowding-out effect' on other company resources. Of course, another situation exists. In the financial market investors are more concerned about the impact of environmental performance on financial performance; however, environmental information disclosure has limited or no impact at all and little attention is paid to it. In addition to the economic consequences of environmental information disclosure, its influencing factors are also the focus of scholarly research. Many internal factors affect the quality of environmental information disclosure. Board diversity, profitability and shareholders' political values are essential factors that affect environmental disclosure policies [8,9]. Additionally, external factors such as an excellent institutional environment, exerting tremendous pressure on stakeholders, and improving corporate internal and external governance mechanisms significantly affect the quality of corporate environmental information disclosure.

As a significant subject of economic development, how enterprises respond and adapt to the requirements of green economic development in the new era is a challenge they are currently facing. Increased transparency in pollution information for industrial companies can stimulate green innovation, and the Porter effect effectively contributes to corporate profitability [10]. Compared to traditional innovation, green innovation is more beneficial in saving resources and reducing environmental pollution [11]. According to market theory, green innovation helps companies build a green image, stimulating new market demand through differentiated competitive advantages. Green innovations gain favour from environmentally conscious consumers, expand market share, and improve financial performance. As a critical way to promote the green transformation of enterprises, green innovation is considered an effective measure for enterprises to achieve a 'win–win' result in terms of economic efficiency and environmental protection. Furthermore, Galbreath [12] considers that board gender diversity and financing constraints influence the relationship between environmental information disclosure and corporate sustainability performance. Women leaders are emotional thinkers and are more sensitive to environmental issues. Financing constraints inhibit the green transformation of companies. According to institutional theory, green innovation is a response to the green transformation system, which helps to avoid administrative penalties in environmental protection, reduce the risk of environmental incidents and the cost of environmental governance, win more investor recognition, and thus reduce financing constraints.

Environmental information disclosure has a practical and significant beneficial impact on improving the quality of environmental governance in developing countries. Currently, the institutional environment for green development in China is not yet perfect. The overall level of government environmental information disclosure quality in China is not high and no province is at an excellent level [13]. This paper aims to clarify the relationship between environmental information disclosure, green innovation, and corporate sustainability performance, and to verify the moderating effects of financing constraints and female directors. Therefore, from the standpoint of internal management, we propose that improving the quality of environmental information disclosure can stimulate enterprises to achieve green technological innovation as a green development strategy to achieve a 'win–win' result for both economic benefits and environmental protection.

2. Research Gaps and Significant Contributions

Research on the economic consequences of environmental information disclosure mainly focuses on its impact on corporate financial and environmental performance, and the relationship remains controversial. Danisch [14] believes that environmental information disclosure significantly and positively affects environmental performance. However, Yang et al. [15] find that environmental information disclosure has a significant negative relationship with the financial performance of listed pharmaceutical companies. From the perspective of sustainable development and environmental, economic theories, companies should increase their profits and pay attention to resource conservation and environmental protection [16]. Therefore, it is interesting to question how we can comprehensively evaluate the impact of environmental information disclosure on corporate performance. The implementation effects of environmental regulations depend on the behavioural choices of enterprises. Jiang et al. [17] find that green credit policy has a significant positive impact on corporate sustainability performance. In addition, Zhao et al. [18] find that environmental taxes have a significant positive relationship with corporate sustainability performance. However, it is essential to highlight that the significant difference between government policies and environmental information disclosure is that green credit policies and environmental taxes are formal environmental regulations. In contrast, environmental information disclosure is an informal environmental regulation with third-party participation. Based on stakeholder theory, there are internal and external stakeholders, and their joint governance is the basic model of modern enterprise development. However, these stakeholders' information interests and goals are not fully aligned or even in conflict. Therefore, it is necessary to take the initiative to improve the quality of companies' environmental information disclosure. This is a crucial decision for business managers concerning sustainable reporting implementation.

According to the Porter hypothesis, implementing environmental regulations will stimulate companies to innovate. The robust version of the Porter hypothesis suggests that the compensatory effect of innovation is greater than the punishment effect and positively impacts companies [19]. However, are the Porter hypothesis and the intense Porter hypothesis applicable to Chinese listed manufacturing companies? We need to pay attention to this question. Are there heterogeneities in the relationship between environmental information disclosure and corporate sustainability performance based on the nature of corporate property rights, environmental attributes and regional characteristics? According to 'pecking order' theory, corporate finance generally follows a sequence of endogenous finance, debt financing and equity financing. However, the financing patterns of companies among countries are different due to different social environments, such as history, culture and institutions, especially corporate systems. Therefore, are there differences in the mod-

erating effects of different external financing channels between environmental information disclosure and corporate sustainability performance in Chinese manufacturing companies?

Moreover, the results of scholarly research on the relationship between environmental information disclosure, green innovation and corporate sustainability performance remain controversial, and there is still a shortage of research from the perspective of financing channels. To answer the above questions, this paper explores the impact mechanism of environmental information disclosure on corporate sustainability performance using balanced panel data of Chinese A-share listed manufacturing companies from 2015 to 2020. The main contributions of this paper are as follows:

- Introducing corporate sustainability performance indicators. We use the entropy method to calculate financial performance and environmental performance weights for determining a comprehensive index of corporate sustainability performance.
- (2) Verifying that environmental information disclosure has a significant positive impact on corporate sustainability performance, which enriches the applicability of the Porter hypothesis in China.
- (3) We find that green innovation has a mediating effect between environmental information disclosure and the corporate sustainability of performance, which reveals the intrinsic transmission mechanism of macroenvironmental policies to microenterprises.
- (4) Replacing the dependent variable and introducing instrumental variables for robustness and endogeneity tests prove the reliability of the paper's findings.
- (5) We use the nature of property rights, environmental attributes and regional characteristics as the grouping basis. This finding verifies that there is no heterogeneity in the relationship between environmental information disclosure and corporate sustainability performance, which enriches the relevant theoretical studies.
- (6) We introduce financing constraints and female directors as moderating variables to verify that high financing constraints inhibit the relationships between environmental information disclosure and corporate sustainability performance. However, due to China's specific historical and cultural characteristics, female directors play only a symbolic role and do not have a positive moderating effect.

The innovation of this paper is that we evaluate the moderating effect of financing constraints. Moreover, we deeply analyse the moderated mediating effects of debt financing and equity financing in the relationship between environmental information disclosure, green innovation and corporate sustainable development performance. This study enriches the theory of green innovation and provides suggestions for sustainable corporate performance and improves government green financial systems. The remainder of the paper is structured as follows.

Section 3 is a theoretical analysis and hypothesis formulation concerning environmental information disclosure, green innovation, corporate sustainability performance and moderating effects. Section 4 represents the descriptive data and model specifications. Section 5 is the presentation of empirical examination and results analysis. Section 6 concerns extended research. Section 7 includes discussion and Section 8 comprises conclusions and recommendations.

3. Theoretical Analysis and Hypothesis Formulation

3.1. Environmental Information Disclosure, Green Innovation and Corporate Sustainability Performance

The impact of business activities on the environment is becoming increasingly severe, and many companies are required to disclose environmental information. Currently, empirical studies on environmental information disclosure have mainly focused on the impact of environmental information disclosure on corporate sustainability performance. Corporate sustainability specifically refers to financial and environmental performance [20,21]. However, the relationships between environmental information disclosure and corporate financial and environmental performance have remained contentious. Chouaibi et al. [22] believe that corporate environmental information disclosure can provide stakeholders and environmental regulators with additional information about companies' values to promote healthy and sustainable development. From the perspective of environmental information disclosure methods, Yin et al. [23] validate that both symbolic and substantive disclosure methods positively impact corporate financial performance, and extended disclosure is more significant. Environmental information disclosure is an essential indicator for investors to measure the attitude of corporate social responsibility and the level of environmental governance. Using the ESG score as an indicator for environmental performance evaluation, Danisch [14] verifies a positive relationship between environmental information disclosure and environmental performance. Environmental information disclosure reduces information asymmetry and agency costs at a certain level and positively promotes enterprises' sustainable development. Jiang et al. [24] construct a composite indicator of high-quality economic development (HQD) in terms of economic environmental and social performance and validate that environmental information disclosure has a positive impact on the high-quality economic development of companies, with intellectual capital playing a mediating effect in this relationship. From the energy-efficiency perspective, environmental information disclosure can reduce environmental pollution and significantly improve corporate energy efficiency. As different industries have particular characteristics of operation and development, environmental information disclosure has various impacts on their financial and environmental performance. For example, Agyemang et al. [25] verify that environmental information disclosure significantly contributes to the growth of the financial performance of listed banks and mining companies. However, there are also opposite findings. Environmental information disclosure has a significant negative correlation with the financial performance of listed pharmaceutical companies. Palm oil listed firms in Southeast Asian countries are the subject of a study by Abdullah et al. [26], which finds that environmental information disclosure has a significant positive correlation with the financial performance of companies in Malaysia, but not in Indonesia.

As the public pays more attention to environmental governance, the monitoring effects of the media become more significant. According to external pressure theory, companies more actively improve the quality of their environmental disclosures when there is more in-depth and high-frequency media coverage. Environmental information disclosure is an effective practice for enhancing corporate reputation and financial performance, and establishing dialogue with stakeholders to improve environmental performance. To summarize the above studies, we propose the following hypotheses:

Hypothesis 1 (H1). *Environmental information disclosure significantly improves corporate sustainability performance.*

Green and low carbon are the main trends of economic transformation and upgrading, and environmental governance significantly drives green innovation in cities to achieve sustainable urban development [27]. There are indirect effects of green innovation in the relationships between environmental information disclosure and economic development and environmental performance from the perspective of urban environmental governance. Feng et al. [28] use urban panel data as a sample to reveal the validity of the mediating effect of green technology innovation between environmental information disclosure and economic development and environmental pollution in static and dynamic situations, respectively, providing a theoretical basis for green, sustainable and high-quality development in China. Lin [29] uses a two-way fixed-effect model to verify that environmental information disclosure can improve the efficiency of urban green economies by increasing the capacity for technological innovation and reducing industrial pollutant emissions. Moreover, environmental information disclosure has the effect of constraining before promoting sustainable development.

As an essential element of corporate internal control, environmental information disclosure promotes green innovation by alleviating agency conflicts and financing constraints. Once the environmental pollution events of companies come to light, tighter government regulation and difficulties in debt financing will have a punitive effect on the company's value. Only through green innovation can companies overcome the long-term pitfalls of environmental pollution and reduce stakeholders' negative expectations of environmental pollution. Therefore, Wu and Qu [30] believe that green innovation activities are beneficial for companies to deal with the pressure of environmental protection and achieve sustainable corporate development. Environmental information disclosure is a significant component of CSR disclosure. Kraus et al. [31] and Mbanyele et al. [32] have explored the mediating effect of green innovation on the relationship between CSR and financial performance and environmental performance from the perspective of CSR disclosure. The requirement for environmental information disclosure and the supervision of environmental public opinion put enormous external pressure on enterprises, stimulating them to take the initiative to develop green technological innovation and increase investment in research. Furthermore, the positive green corporate image enhances corporate environmental reputation and strengthens corporate business credit and eases financing constraints. Green innovation is undoubtedly the best method for enterprises to achieve green development and safeguard public interests and is conducive to achieving a 'win-win' result for both environmental protection and enterprise development. Based on this, this paper puts forward the following hypothesis:

Hypothesis 2 (H2). *Green innovation has a significant positive relationship with environmental information disclosure, and plays a mediating effect in the relationship between environmental information disclosure and corporate sustainability performance.*

3.2. Moderating Effects of Financing Constraints and Female Directors

In green finance, listed companies transform the external pressure of environmental information disclosure into internal motivation, which is key to achieving environmental governance goals. Environmental information helps to increase the cumulative effect of information and reduce information asymmetry. Furthermore, it provides a space for stakeholders to communicate with business entities, reduces barriers to accessing capital markets and lowers financing costs, thereby effectively alleviating financing constraints [33]. Green innovation activities' long-term and high-risk characteristics make companies suffer from financing costs and high adjustment costs [34]. When financial institutions consider environmental risks when lending to companies, the more debt covenants there are between companies and banks, the higher the quality of the environmental information that needs to be disclosed. Ding et al. [35] find that environmental penalties are an important influencing factor on corporate environmental information disclosure. The decrease in environmental information disclosure quality by penalised companies leads to higher financing costs. Using a fixed-effect model, Luo et al. [36] verify that the quality of corporate environmental information disclosure dramatically negatively impacts the cost of debt financing. Additionally, Zhang et al. [37] reveal that green technology innovation and green management innovation can significantly reduce the level of corporate financing constraints by introducing instrumental variables and the propensity score matching (PSM) method. Based on signalling theory, companies disclose environmental information and actively engage in green innovation to signal to the outside that they are making a green transition. A better green image helps to attract more investors' attention, thus improving the financing environment and enhancing the relationship between environmental information disclosure and financial and environmental performance. Based on this, we propose the following hypothesis:

Hypothesis 3 (H3). *High financing constraints inhibit the relationships between environmental information disclosure and corporate sustainability performance.*

Board gender diversity (BGD) is one of the characteristics of corporate governance structures based on the perspective of group diversity and social roles. Compared to male directors, female directors are more environmentally conscious and more willing to proactively disclose corporate environmental information, strengthen environmental investments and take social responsibility to safeguard the interests of stakeholders and the public [38]. Green innovation is one of the most important approaches to improving the ability of corporate environmental governance and the level of financial performance. As such, it receives more attention and support from female directors. Female directors mitigate principal–agent conflicts through effective internal supervision mechanisms, and promote innovation output and R&D productivity. Nerantzidis et al. [39] use a panel vector autoregressive (PVAR) model to verify that board gender diversity (BGD) has a significant positive correlation with the social performance (CSP) of European listed companies. Taking a sample of listed companies from 43 countries, Rjiba and Thavaharan [40] reveal that board gender diversity significantly reduces corporate carbon emissions. As female leadership continues to improve, the natural characteristics of female directors are beneficial not only for the innovative performance of employees but also for the green development of companies. Thus, the following hypothesis is proposed:

Hypothesis 4 (H4). *Female directors positively moderate the relationship between environmental information disclosure and corporate sustainability performance.*

3.3. Moderating Effects of Debt Financing and Equity Financing

As the two most important exogenous financing modes, debt and equity financing have different effects on the corporate green transformation stages. The implementation of green credit policy results in financial institutions being more sensitive to environmental information, making it easier for companies to obtain low-interest loans for green innovation projects. According to the Porter hypothesis, environmental regulation stimulates enterprises to improve their ability to combat pollution and the technological content of their products, creating an 'incentive effect' on investment in technological innovation [5]. However, equity investors are more concerned with financial performance and less sensitive to environmental information disclosure. In addition, equity financing takes longer to obtain and does not ease the financing pressure timely.

Technological innovation, with its long-term and high-risk characteristics and the lagging effect of innovation compensation, may not offset the high adjustment and debt financing costs. Financial leverage increase can significantly raise the level of corporate insolvency risk. From the signalling theory perspective, green innovation projects need to attract significant external financing, and conditional conservatism can reduce the information asymmetry costs between companies and shareholders, but does not significantly impact the information asymmetry costs between companies and debt holders [41]. With changes in the external economic environment, equity financing has a greater risk tolerance than debt financing in the long term.

In summary, we believe there is a significant difference between the moderating effects of debt financing and equity financing in the relationships among environmental information disclosure, green innovation and corporate sustainability performance. Using debt financing and equity financing interchangeably is the optimal financing strategy for companies in the process of green innovation. Thus, the following hypothesis is proposed:

Hypothesis 5 (H5). Debt financing and equity financing have different moderating effects on the relationships among environmental information disclosure, green innovation and corporate sustainability performance.

We develop a research model based on the above research hypothesis in this paper. This model is shown in Figure 1.

To further explore the moderating mechanism of financing constraints in the economic consequences of environmental information disclosure, this paper focuses on the differences in the moderating effects of different financing channels from the perspective of debt financing and equity financing.



Figure 1. Conceptual model.

4. Descriptive Data and Model Specifications

4.1. Sample Selection and Data Sources

Manufacturing companies have more serious environmental pollution problems and are under more significant external pressure from environmental regulation. Therefore, the data of Chinese A-share listed manufacturing companies from 2015 to 2020 are selected as a sample in this paper to explore the logical relationship between environmental information disclosure, green innovation and sustainable corporate performance. Companies with missing variable data and ST or *ST are removed to ensure data validity. Of these, companies with financial abnormalities and 'special treatment' by the Stock Exchange are referred to as 'ST'; the stock is not only under 'special treatment', but also has three consecutive years of deficits, such companies at risk of delisting are referred to as '*ST'. Finally, we get 2694 observations for 449 companies. The authors used data for measuring green innovation and environmental performance from the Chinese Research Data Services (CNRDS), environmental information disclosure and financial performance data are used from the China Stock Market and Accounting Research Database (CSMAR), and the remaining data are from the WIND database.

4.2. Variable Identification and Sample Description

4.2.1. Dependent Variables

Referencing the research of [16], this paper divides corporate sustainability performance into two dimensions: financial and environmental. We use the entropy method to assign weights to environmental performance and financial performance, and the composite score obtained for each company annually is used as the sustainability performance index. According to the factor pricing model in neoclassical finance theory, the bookto-market ratio is a vital pricing factor that can measure the future growth potential of companies [42]. The listed company is the most critical component of the capital market, and we use the book-to-market ratio as an indicator to measure corporate financial performance. Furthermore, this paper measures environmental performance in three dimensions: key pollution monitoring units, sudden environmental accidents and passing ISO 14001 certification. The sum of the three items is the environmental performance score. The scoring method is shown in Table A1 (Appendix A).

4.2.2. Independent Variables

This paper constructs a measurement system for environmental information disclosure from ten dimensions, such as the environmental protection concept, environmental protection goal and environmental protection management system. The sum of the ten items is the quality of the environmental information disclosure score. The scoring method is shown in Table A1.

4.2.3. Mediating Variables

Following the research of [43], green innovation is set as the number of independent and joint applications for green inventions by companies. We chose the number of green invention applications rather than the number of grants because there is a lag in the patent granting progress. Green technologies may already play a role in applying for patents by companies, so the number of applications better reflects the proper level of green innovation.

4.2.4. Moderating Variables

Board gender diversity and capital are essential factors influencing companies to engage in green innovation. The technological innovation activities' long-term and highrisk characteristics determine that they face high financing and adjustment costs. From the social psychology perspective, women and men differ in their attitudes towards risk, investment, finance, decision-making and leadership styles. The attitude of board members towards environmental protection is an essential prerequisite for companies to implement green development strategies. Female directors are more sensitive to stakeholder demands and they are more willing to take the initiative to take environmental responsibility to reduce the damage of environmental pollution to the public [44,45]. With the increasing influence of female directors, gender diversity on the board is conducive to sustainable corporate behaviour. However, in China's particular social environment, with traditional gender attitudes deeply rooted, it is interesting to see whether female leadership can really affect significant decision-making. As such, we use financing constraints and female directors as moderating variables to comprehensively analyse their moderating effects on the relationship between environmental information disclosure and corporate sustainability performance, respectively. This paper refers to [46], which measures financing constraint intensity using the SA index. A higher value indicates that the company has a more substantial level of financing constraints. The SA index is constructed as:

$$SA = -0.737 Size + 0.043 Size^2 - 0.040 Age$$

where

Size is the natural logarithm of total assets,

The age is defined as the number of years after the firm goes public.

Since exogenous financing has a more significant contribution to green technology innovation than endogenous financing [47], the panel regression is conducted using debt financing and equity financing as the moderating variables. We analyse the differences in their moderating effects of the relationship between environmental information disclosure, green innovation and corporate sustainability performance.

4.2.5. Control Variables

We select corporate leverage, growth, property rights, percentage of independent directors, age of the business, and dual role as control variables. The definitions of the specific variables involved in this paper and their descriptive statistics are presented in Table 1. Significant differences in sustainability performance can be observed among companies.

Variable Category	Specific Indicators	Signs	Variable Description	Data Sources	Mean	Min	Max
	Financial Performance	Bm	Equity to Market Capitalisation	CNRDS	0.587	0.045	1.346
 Dependent variables	Environmental Performance	Ksi	3 items including key pollution monitoring units	database CSMAR	0.713	0.000	2.000
	Corporate Sustainability Performance	Csp1	A composite index calculated by the entropy method	database	0.366	0.004	0.992
Independent variables	Environmental Information Disclosure	Eid	10 items including environmental protection concept and goal	CSMAR database	2.999	0.000	10.000
Mediator	Green Innovation	Gin	Number of independent and joint applications for green inventions	CNRDS database	4.695	0.000	424.000
_	Financing Constraints	Fci	SA Index		4.612	1.605	11.408
	The ratio of female directors	Fdr	Ratio of female directors to total board members	0.148		0.000	0.714
Moderator	Debt Financing	Def	The natural logarithm of the sum of long-term and short-term debts			0.000	25.672
_	Equity Financing	Eqf	The sum of paid-in capital and capital reserves as a percentage of total assets		0.168	0.012	1.403
	Leverage Ratio	Lev	Ratio of liabilities to assets	WIND Database	0.392	0.014	0.979
	Enterprise growth	Growth	Operating revenue growth rate	Database	0.233	-1.125	10.455
	Type of shareholding	State	State-owned enterprises as 1, otherwise as 0	0.392		0.000	1.000
Control variables	Ratio of independent directors	Idr	Ratio of independent directors to total board members			0.200	0.800
_	Years in business operation	Age	Period from the establishment of the business to the present time		19.097	6.000	39.000
	Dual role	Isd	Serve as both chairman and general manager as 1, otherwise as 0		0.258	0.000	1.000

Table 1. Variable definitions and descriptive statistics.

4.3. Empirical Model Construction

To test H1, the regression models of environmental information disclosure and corporate sustainability performance are constructed:

$$Csp1_{it} = \beta_0 + \beta_1 Eid_{it} + \beta_2 Controls_i^t + Fixedeffects + \varepsilon_i^t$$
(1)

To test H2, based on Model (1), green innovation is introduced into the following models to test the transmission effect of technological innovation between environmental information disclosure and corporate sustainability performance:

$$Csp1_{it} = \beta_0 + \beta_1 Eid_{it} + \beta_2 Gin_{it} + \beta_3 Controls_i^t + Fixedeffects + \varepsilon_i^t$$
(2)

$$Cin_{it} = \beta_0 + \beta_1 Eid_{it} + \beta_2 Controls_i^t + Fixedeffects + \varepsilon_i^t$$
(3)

$$Gin_{it} = \beta_0 + \beta_1 Eid_{it} + \beta_2 Controls_i^t + Fixedeffects + \varepsilon_i^t$$
(3)

To test H3 and H4, we construct models of the moderating effects of financing constraints and female directors on the relationships between environmental information disclosure and corporate sustainability performance, respectively:

$$Csp1_{it} = \beta_0 + \beta_1 Eid_{it} + \beta_2 Fci_{it} + \beta_3 Eid_{it} * Fci_{it} + \beta_4 Controls_i^t + Fixedeffects + \varepsilon_i^t \quad (4)$$

$$Csp1_{it} = \beta_0 + \beta_1 Eid_{it} + \beta_2 Fdr_{it} + \beta_3 Eid_{it} * Fdr_{it} + \beta_4 Controls_i^t + Fixedeffects + \varepsilon_i^t$$
(5)

To test H5, we construct models of the moderating effects of debt financing and equity financing on the relationships between environmental information disclosure, green innovation and corporate sustainability performance, respectively:

$$Csp1_{it} = \beta_0 + \beta_1 Eid_{it} + \beta_2 Def_{it} + \beta_3 Eid_{it} * Def_{it} + \beta_4 Controls_i^t + Fixedeffects + \varepsilon_i^t$$
(6)

$$Gin_{it} = \beta_0 + \beta_1 Eid_{it} + \beta_2 Def_{it} + \beta_3 Eid_{it} * Def_{it} + \beta_4 Controls_i^t + Fixedeffects + \varepsilon_i^t$$
(7)

$$Csp1_{it} = \beta_0 + \beta_1 Eid_{it} + \beta_2 Eqf_{it} + \beta_3 Eid_{it} * Eqf_{it} + \beta_4 Controls_i^t + Fixedeffects + \varepsilon_i^t$$
(8)

$$Gin_{it} = \beta_0 + \beta_1 Eid_{it} + \beta_2 Eqf_{it} + \beta_3 Eid_{it} * Eqf_{it} + \beta_4 Controls_i^t + Fixedeffects + \varepsilon_i^t$$
(9)

where *i* is the *i*th firm, *t* is the *t*th year, β is the coefficient, Controls is the set of control variables, Fixedeffects is the two-way fixed effects, ε_i^t is the residual.

5. Empirical Examination and Results Analysis

5.1. Environmental Information Disclosure, Green Innovation and Corporate Sustainability Performance

When we use the time effect model, years of the enterprise are absorbed. Therefore, we only use the entity fixed-effect model to analyse the intrinsic logical relationships between the variables. Table 2, Model (1) shows that environmental information disclosure positively affects corporate sustainability performance at the 1% level. This finding fully supports H1. The higher corporate environmental information disclosure quality, the more significant the contributions to sustainability performance. Additionally, a year of business has a significant positive impact on corporate sustainability performance.

Model (2) shows that environmental information disclosure positively impacts green innovation at the 1% level. Environmental information disclosure as an informal environmental regulation can significantly stimulate companies to increase their investment in green technology innovation. Model (3) shows that environmental information disclosure has a positive effect on sustainability performance at the 1% level, and green innovation positively affects sustainability performance at the 10% level. Thus, according to the mediating effect test process [48], environmental information disclosure has a positive impact on corporate sustainability performance through green innovation. Green innovation plays a partial mediating effect in the relationship between environmental information disclosure and corporate sustainability performance. H2 is also fully supported. As mentioned above, environmental information disclosure can directly improve corporate sustainability performance, and enhance corporate sustainability performance through green innovation.

Table 2. Results of Environmental Information Disclosure, Green Innovation and Enterprise Sustainability Performance.

Den Verichle	Model (1)	Model (2)	Model (3)
Dep. variable –	Csp1	Gin	Csp1
Eid	0.045 ***	0.767 ***	0.045 ***
	(13.30)	(3.85)	(13.12)
Lev	-0.000	0.543	-0.001
	(-0.01)	(0.14)	(-0.01)
Growth	-0.015	0.149	-0.016
	(-1.49)	(0.25)	(-1.50)

Model (1)	Model (2)	Model (3)
Csp1	Gin	Csp1
0.077	-2.031	0.078
(1.55)	(-0.70)	(1.57)
-0.015	-2.410	-0.013
(-0.10)	(-0.29)	(-0.09)
0.024 ***	-0.272 *	0.024 ***
(9.51)	(-1.85)	(9.58)
0.019	-0.258	0.019
(1.05)	(-0.24)	(1.06)
		0.001 *
		(1.71)
-0.253 ***	9.101 **	-0.258 ***
(-3.46)	(2.13)	(-3.54)
Entity	Entity	Entity
2694	2694	2694
0.162	0.007	0.163
	Model (1) Csp1 0.077 (1.55) -0.015 (-0.10) 0.024 *** (9.51) 0.019 (1.05) -0.253 *** (-3.46) Entity 2694 0.162	Model (1)Model (2)Csp1Gin 0.077 -2.031 (1.55) (-0.70) -0.015 -2.410 (-0.10) (-0.29) 0.024 *** -0.272 * (9.51) (-1.85) 0.019 -0.258 (1.05) (-0.24) -0.253 *** 9.101 ** (-3.46) (2.13) EntityEntity 2694 2694 0.162 0.007

Table 2. Cont.

Note: *, **, *** Significant at 10%, 5% and 1% confidence levels, respectively, with t-stats in parentheses. Same as below.

5.2. Moderating Effects of Financing Constraints and Female Directors

We use the two-way fixed-effect model to test the moderating effects of financing constraints and female directors to control for endogeneity. In Table 3, Model (1) shows that the interaction term between environmental information disclosure and financing constraints negatively correlates with corporate sustainability performance at the 5% level. H3 is fully supported by this finding. When companies face lower financing constraints, increasing their investment in green innovation is more beneficial. Thus, financing constraints positively moderate the impact of environmental information disclosure on corporate sustainability performance. While strengthening financing supervision, the government should broaden financing channels, encourage private financing and optimize the green financial system to support the green development of enterprises.

Der Verichle	Model (1)	Model (2)	
Dep. variable -	Csp1	Csp1	
Eid	0.062 ***	0.043 ***	
	(6.29)	(10.42)	
Fci	-0.019		
	(-1.02)		
Fdr		0.071	
		(0.95)	
Eid*Fci	-0.005 **		
	(-2.48)		
Eid*Fdr		-0.031 *	
		(-1.73)	
Lev	0.040	0.013	
	(0.62)	(0.22)	
Growth	-0.013	-0.013	
	(-1.29)	(-1.31)	
State	0.082 *	0.081 *	
	(1.74)	(1.72)	

Table 3. Moderating Effects of Financing Constraints and Female Directors.

D 11	Model (1)	Model (2)
Dep. variable -	Csp1	Csp1
Idr	-0.045	-0.050
	(-0.34)	(-0.38)
Isd	0.016	0.015
	(0.94)	(0.88)
Intercept	0.308 ***	0.222 ***
	(3.07)	(3.66)
	Entity	Entity
Effects	Time	Time
Observations	2694	2694
R-Squared	0.065	0.062

Table 3. Cont.

Note: *, **, **** Significant at 10%, 5% and 1% confidence levels, respectively, with t-stats in parentheses. Same as below.

In model (2), the interaction term between environmental information disclosure and female directors is negatively related to corporate sustainability performance at the 10% level. This study indicates that female directors negatively moderate the effect of environmental information disclosure on corporate sustainability performance. H4 does not support this finding. The main reason for this is the gender imbalance in the board of directors in China due to outmoded notions and inequitable socioeconomic structures. The mismatch between female directors and corporate characteristics has resulted in female directors not playing a substantive role in major environmental decisions, but only a symbolic role [49]. Moreover, women's risk-aversion tendency in business decisions could actively forgo high-risk innovative investment projects.

5.3. Robustness and Endogeneity Tests

Environmental information disclosure significantly improves corporate sustainability performance. To avoid inaccurate findings due to missing variables, this paper uses the replacement of explained variables and the introduction of instrumental variables for robustness and endogeneity tests. We replace the book-to-market ratio with market capitalization. A new environmental performance measurement system is constructed to retest the impact of environmental information disclosure on corporate environmental performance in terms of standard-reaching of pollutant discharge, environmental violation event and passing ISO 9001 certification. Thus, we calculate a new corporate sustainability performance index (Csp2) using the entropy method. In Table 4, Model (1) shows that environmental information disclosure positively affects environmental performance at the 1% level.

Table 4	. Robustness	and Endo	geneity	Tests
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Dan Variable	Model (1)	Model (2)	Model (3)
Dep. variable	Csp2	Csp1	Csp1
Eid	0.004 ***	0.061 ***	0.063 ***
	(4.94)	(20.64)	(22.05)
Control variables	Yes	Yes	Yes
Intercept	0.318 ***	0.109 **	0.135 ***
	(16.55)	(2.16)	(3.09)
Effects	Entity	-	-
No. Observations	2694	2245	2245
R-Squared	0.025	-	0.283

Note: **, *** Significant at 5% and 1% confidence levels, respectively, with t-stats in parentheses. Same as below.

There may be an inverse causality between environmental information disclosure, green innovation and corporate sustainability performance, leading to endogeneity in the regression results. To reduce the estimation bias caused by endogeneity, this paper retests the explanatory and control variables with a one-period lag as instrumental variables and replaces the model. We conduct regression analysis using the generalized method of moment (GMM) model, which shows that environmental information disclosure positively impacts corporate sustainability performance at the 1% level in the Model (2). We carry out regression analysis using the two-stage least square (2SLS) model, which shows that environmental information disclosure also has a positive impact on corporate sustainability performance at the 1% level in Model (3). We introduce instrumental variables and test them using GMM and 2SLS models, and the results do not contradict the findings of this paper. In summary, the results of the empirical tests replacing the dependent variables and introducing instrumental variables are entirely consistent with the findings of this paper, indicating that the findings are very reliable.

5.4. Heterogeneity Test

This paper refers to existing research findings and analyses heterogeneity in two dimensions: the internal characteristics of companies and the external environment. The nature of property and environmental attributes are selected for the internal characteristics of enterprises, and the regional characteristics are selected for the external environment as the grouping basis. Table 5 shows that environmental information disclosure has a significant positive relationship with corporate sustainability performance at the 1% level in all groupings. Therefore, there is no heterogeneity in the relationship between environmental information disclosure and corporate sustainability performance. The nature of ownership grouping show results that environmental information disclosure has a more significant impact on corporate sustainability performance by non-state-owned enterprises (SOEs).

	Property	Rights Nature	Regional Po		Pol	lution
Classifications	State Owned	Non-State-Owned	East	Non-East	Heavy Pollution	Non-Heavy Pollution
Dep. Variable	Csp1	Csp1	Csp1	Csp1	Csp1	Csp1
Eid	0.044 *** (7.65)	0.047 *** (10.98)	0.048 *** (11.14)	0.041 *** (7.38)	0.048 *** (9.42)	0.043 *** (9.46)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	-0.252 *	-0.153 *	-0.232 ***	-0.278 **	-0.013	-0.413 ***
1	(-1.91)	(-1.65)	(-2.72)	(-1.99)	(-0.11)	(-4.66)
Effects	Entity	Entity	Entity	Entity	Entity	Entity
Observations R squared	1057	1637 0 193	1794 0 177	900 0.140	1303	1391
K-squared	0.125	0.195	0.177	0.140	0.140	0.199

Table 5. Results of the Heterogeneity Test.

Note: *, **, *** Significant at 10%, 5% and 1% confidence levels, respectively, with t-stats in parentheses. Same as below.

The results of the regional groupings show that environmental information disclosure has a more substantial impact on the corporate sustainability performance by enterprises in the east than by those not in the east. The high degree of marketisation, a well-developed market economy, and better information transparency in the eastern regions make companies disclose higher-quality environmental information, which will more directly signal to stakeholders that they are responsible and more likely to attract capital to improve their sustainability performance. According to the environmental industry classification management list (circular letter 2008 no. 373) and the industry classification methods of the China Securities Regulatory Commission (2012 version), 10 subsectors in the manufacturing industry, including petroleum processing and pharmaceutical manufacturing, are classified as heavily polluting industries, while the remaining 16 subsectors are classified as nonheavily polluting industries. The results of the environmental attribute grouping show that environmental information disclosure has a stronger impact on the corporate sustainability performance of heavily polluting enterprises than non-heavily polluting enterprises.

6. Extended Research

To further test the moderating mechanism of financing constraints in the economic consequences of environmental information disclosure, this paper focuses on the heterogeneity generated by different financing channels. Table 6 shows significant differences in the moderating effects of different sources of exogenous financing on the economic consequences of environmental information disclosure. Model (1) shows that debt financing inhibits the positive impact of environmental disclosure on corporate sustainability performance. In the long term, the high adjustment costs and high risk of uncertain returns of innovation activities often make R&D activities face financial limitations. The initial investment in green innovation creates vast sunk costs. The high leverage created by debt financing can put companies in financial difficulty and increase the risk of bankruptcy and liquidation, thus failing to stimulate innovation. Additionally, the innovation compensation-effect lag creates difficulties for companies in making timely interest payments. Thus, debt financing inhibits the impact of environmental information disclosure on corporate sustainability performance. However, Model (3) shows that it promotes the positive impact of environmental disclosure on green innovation. In the short term, high-quality environmental information disclosure eases the information asymmetry between banks and companies, which helps companies to access credit facilities at lower costs. Moreover, the improved green credit system provides a lower cost of debt capital for enterprises to engage in green innovation, easing their financing pressure in the short term. Thus, debt financing contributes to the impact of environmental information disclosure on green innovation.

Der Verichle	Model (1)	Model (2)	Model (3)	Model (4)
Dep. Variable	Csp1	Csp1	G	in
Eid	0.051 ***	0.023 ***	-0.218	1.835 ***
	(7.35)	(3.95)	(-0.51)	(5.03)
Def	0.001		-0.023	
	(0.39)		(-0.30)	
Eqf		0.153 *		3.109
		(1.75)		(0.58)
Eid*Def	-0.001 **		0.047 **	
	(-2.10)		(2.33)	
Eid*Eqf		0.051 ***		-3.897 ***
		(3.09)		(-3.84)
Control varials	Yes	Yes	Yes	Yes
Intercept	0.212 ***	0.109	5.327	4.484
	(3.40)	(1.40)	(1.39)	(0.94)
Effects	Entity	Entity	Entity	Entity
Effects	Time	Time	Time	Time
No. Observations	2694	2694	2694	2694
R-Squared	0.0631	0.0694	0.0086	0.0124

Table 6. Moderating Effects of Financing Mechanisms.

Note: *, **, *** Significant at 10%, 5% and 1% confidence levels, respectively, with t-stats in parentheses. Same as below.

Model (2) shows that equity financing promotes the positive impact of environmental disclosure on corporate sustainability performance. Equity financing can bring long-term cash inflows to companies, matching the long-term character of equity financing with the long-term character of R&D activities. Therefore, equity financing is more likely to maintain

the innovative vitality of companies and contribute to their growth value. However, Model (4) shows that it inhibits the positive impact of environmental information disclosure on green innovation. Thus, H5 is fully supported. The environmental information disclosure system in China is not yet complete, the self-interested impression management green-washing behaviour of companies results in actual green innovative companies not being able to send positive signals about their environmental protection behaviour in the capital market in the short term. As a result, equity financing has failed to fully develop its positive moderating effect in the relationship between environmental information disclosure and green innovation.

In this paper, we use the bootstrap method to test further whether there are moderated mediating effects of debt financing and equity financing in different routes. The algorithm follows Model (8) in the process procedure [50]. The test results are shown in Table 7, where debt financing and equity financing have no moderated mediating effects on the relationship between environmental information disclosure and corporate sustainability performance.

 Table 7. The Results of Tests for Moderated Mediation.

Enterprise Performance	Moderator	Mediator	Index	Boot SE	LLCI	ULCI
Csp1	Def Eqf	Gin	-0.0000 0.0016	0.0000 0.0013	$-0.0001 \\ -0.0012$	$0.0000 \\ 0.0041$

Note: BootLLCI is the 95% lower confidence limit, BootULCI is the 95% upper confidence limit.

Based on the above analysis, we get the following findings: environmental information disclosure has a significant positive impact on corporate sustainability performance $(\beta = 0.045, p < 1\%)$. Furthermore, green innovation has a mediating effect. Then, we find that financing constraints negatively moderate the relationship between environmental disclosure and corporate sustainability performance ($\beta = -0.005$, p < 5%); female directors also negatively moderate the relationship ($\beta = -0.031$, p < 10%). The robustness test replacing the dependent variable shows that there is a significant positive relationship ($\beta = 0.004$, p < 1%). Endogeneity tests introducing instrumental variables also verify the reliability of findings. The GMM regression finds a significant positive relationship $(\beta = 0.061, p < 1\%)$; and 2SLS regression also gets the same result ($\beta = 0.063, p < 1\%$). Heterogeneity tests find no heterogeneity in the relationship between environmental information disclosure and corporate sustainability performance. However, non-SOEs, eastern, and heavily polluting enterprises are more sensitive to environmental information disclosure. We further analyse the difference of the moderating effects between debt financing and equity financing in the economic consequences of environmental information disclosure. Debt financing negatively moderates the relationship between environmental information disclosure and corporate sustainability performance ($\beta = -0.001$, p < 5%), but positively moderates the relationship between environmental information disclosure and green innovation ($\beta = 0.047$, p < 5%); equity financing positively moderates the relationship between environmental information disclosure and corporate sustainability performance ($\beta = 0.051$, p < 1%), but negatively moderates the relationship between environmental information disclosure and green innovation ($\beta = -3.897$, p < 1%). Finally, we test the moderation-mediating effects using the bootstrap method. The results show that the 95% confidence interval [-0.0001, 0.0000] for debt financing contains 0, which shows no moderating mediating effect, and the 95% confidence interval [-0.0012, 0.0041]for equity financing contains 0, which also shows no moderating mediating effect.

7. Discussion

Environmental information disclosure is one of the informal forms of environmental regulation, so we need to study its economic consequences. We find that environmental information disclosure has a significant positive impact on corporate sustainability per-

formance through green innovation, which validates the existence of the Porter effect in the Chinese manufacturing industry. This finding is consistent with the result of [51]. The lower the intensity of financing constraints, the more it promotes the positive impact of

lower the intensity of financing constraints, the more it promotes the positive impact of environmental information disclosure on corporate sustainability performance. Female directors do not play a substantive role in major environmental decisions, but only a symbolic role. We validate the reliability of the findings in this paper using the replacement of dependent variables and the introduction of instrumental variables.

Although companies' ownership, regional characteristics and environmental attributes differ, the economic consequences of environmental information disclosure do not make a significant difference. Environmental information disclosure and media supervision as informal environmental regulations put tremendous pressure on corporate environmental governance. Meanwhile, the government implements more burdensome environmental regulations and higher penalties make breaking the law significantly more expensive. SOEs have stable R&D and investment budgets compared to non-SOEs, thus reducing the impact of environmental pollution on the cost of debt [52]. Furthermore, the natural political connections of SOEs can amplify their green image, making them less sensitive to environmental disclosure. Non-SOEs face higher financing constraints and have to improve the quality of environmental information disclosure to attract more investment for improving green innovation. Finally, non-SOEs can achieve a 'win–win' outcome regarding their environmental and financial performances. According to the regional economic division of China, the eastern region has unique geography, substantial capital, and a high level of technology and environmental awareness compared to the central, western and northeast regions [53]. As heavily polluting enterprises have a more significant impact on environmental pollution, they face higher pressure for external supervision. Meanwhile, their business directions are more likely to attract the public's attention. Most heavily polluting companies are capital-intensive and traditional. By improving the quality of environmental information disclosure, green transformation can more significantly contribute to corporate sustainability performance. Thus, non-SOEs with high financing constraints, highly market-oriented eastern regions and traditional heavily polluting enterprises are more significant in the positive effect of environmental information disclosure on corporate sustainability performance.

Green credit is an essential financial instrument promoting green innovation in business. Zhang et al. [54] point out that implementing green credit policies inhibit green innovation by heavily polluting companies. However, from the perspective of financing mechanisms, we extend our research and obtain new findings that in the short term, companies can use debt financing to alleviate financing constraints for green innovation. Debt financing promotes the positive impact of environmental information disclosure on green innovation. This indicates that the debt financing market supports green innovation more strongly, which may be due to implementing the Green Credit Guidelines and other relevant policies. Financial institutions, mainly commercial banks, have opened green channels for green innovative enterprises, making it possible for green transformation enterprises to enjoy more preferential treatment in debt financing. In the long term, equity financing positively moderates the relationship between environmental information disclosure and corporate sustainability performance. This is because the long-term stable and improving Chinese economy creates a favourable environment for developing the capital market. The gradual perfection of the stock-market supervision system provides institutional guarantees for stakeholders. Equity financing effectively reduces financial leverage and financial risks to promote sustainable corporate development. The findings provide references for the financing channels for enterprises engaging in green innovation and provide a theoretical basis for the government to perfect the green financial system.

Of course, this paper still has shortcomings in the research process. The insufficient disclosure of corporate financial data results in a lack of large numbers of sample companies. We only analyse the moderating effect of financing constraints and do not analyse in depth the effects of major factors such as corporate governance and board diversity char-

acteristics [55]. Additionally, although we verify that environmental disclosure promotes corporate green transformation to a certain extent, it has a limited effect as an informal environmental regulation. Green innovation can improve the enterprises' financial, environmental and social performance after implementing a green credit policy. Therefore, we will take green finance policies' impact on corporate performance as our next research direction. Using the green credit policy enacted by the Chinese Banking Regulatory Commission as a quasi-natural experiment, propensity matching score and differences in different methods are combined to construct a PSM-DID model. Meanwhile, technological innovation is the main factor driving enterprises' green transformation, and debt financing provides capital support for technological innovation. Thus, we will explore the impact mechanism of green credit policy on sustainable corporate performance from the perspective of technology innovation level and credit resource allocation. In the context of the environmental targets of 'carbon peaking' and 'carbon neutrality', implications for the green transformation of enterprises and the improvement of the green financial system will be proposed.

8. Conclusions and Recommendation

Based on Chinese A-share listed manufacturing companies during 2015–2020, we construct a two-way fixed-effect model to explore the impact mechanism of environmental information disclosure on corporate sustainability performance. Our findings support H1, H2, H3 and H5. However, due to the exceptional social environment in China, female directors do not play a key role in major decisions and have only a symbolic effect, which is opposite to our H4. Compared to other studies, we not only analyse the moderating effect of financing constraints but also further analyse the differences in the moderating effects of different exogenous financing channels on the economic consequences of environmental information disclosure. This paper finds no mediating effects of debt financing or equity financing on the relationship between environmental information disclosure, green innovation and corporate sustainability performance. Thus, our research enriches the studies on the economic consequences of environmental information disclosure, and the results have implications for business operators, investors and government departments:

- (1) Enterprises should establish an R&D model centred on green innovation. Given their leading role in the market, they should promote clean production and develop green and low-carbon industries. By proactively disclosing corporate environmental information and focusing on the granting and promotion of green patents to promote the efficient use of low-carbon energy and active green innovation. Paying attention to the output of original green R&D results, the policy dividend should be fully absorbed, and a perfect mechanism for converting innovation results should be established. High-quality environmental information disclosure becomes a powerful instrument for resource allocation, and only then can companies be continuously stimulated to engage in green innovation to maintain their competitive advantages.
- (2) Financial departments should continue to perfect the green financial system and promote supply-side structural reform towards green supply. Setting up a sound legal system for green credit can effectively provide financing convenience for green enterprises. The green transformation of key industries and important sectors can be accelerated by financial institutions actively guiding enterprises towards green development. Switching the focus to green, low-carbon and sustainable development can attract more social capital to environmentally friendly enterprises.
- (3) Supervising departments should develop a sound mechanism for sharing the environmental data of enterprises. The content and form of environmental information disclosure should be standardized to avoid environmental fraud and to prevent enterprises from 'greenwashing' behaviour that damages the interests of society [56]. These measures promote enterprises green development and the green transformation of industrial structures more efficiently.
- (4) Local authorities should increase their financial support for corporate green innovation, guide enterprises to fulfil their social responsibilities and improve the quality

of environmental information disclosure. Government subsidies not only provide direct R&D funding for enterprises but also provide halo effects that stimulate them to disclose environmental information willingly. Moreover, green images attract social investment and increase external financing for companies to directly promote innovation efficiency [57].

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Appendix A

Table A1. The Measurement Systems of Environmental Information Disclosure and Environmental Performance.

Variables	Secondary Indicators	Definitions		
	Environmental Protection Concept	Disclosure of the companies' environmental protection concept, policy, environmental management organization structure, circular economy development model, green development, etc. Assign a value of 1 to the above disclosure, otherwise 0.	1/10	
Environmental Information Disclosure	Environmental Protection Goal	Disclosure of the companies' achievement of past and future environmental protection goals. Assign a value of 1 to the above disclosure, otherwise 0.	1/10	
	Environmental Protection Management System	Disclosure of a series of management systems, such as relevant environmental management systems, regulations and responsibilities formulated by companies. Assign a value of 1 to the above disclosure, otherwise 0.		
	Environmental Protection Education and Training	Disclosure of the environmental protection education and training that companies have participated in. Assign a value of 1 to the above disclosure, otherwise 0.	1/10	
	Environmental Protection Special Action	Disclosure of special environmental protection activities, environmental protection and other social welfare activities that companies have participated in. Assign a value of 1 to the above disclosure, otherwise 0.	1/10	

Variables	Secondary Indicators	Definitions	Value Weight
Environmental Information Disclosure	Environmental Event Emergency Mechanism	Disclosure of the companies' establishment of emergency mechanism for major events related to environment, emergency measures taken, and treatment of pollutants, etc. Assign a value of 1 to the above disclosure, otherwise 0.	1/10
	Environmental Protection Honours or Awards	Disclosure of the companies' honours or awards in environmental protection. Assign a value of 1 to the above disclosure, otherwise 0.	1/10
	Three Simultaneous System	Disclosure of the companies' implementation of 'Three simultaneity' system. Assign a value of 1 to the above disclosure, otherwise 0.	1/10
	Social Responsibility Report	Relevant environmental information disclosed in corporate social responsibility report by listed companies. Assign a value of 1 to the above disclosure, otherwise 0.	1/10
	Environmental Report	Environmental report disclosed separately by listed companies. Assign a value of 1 to the above disclosure, otherwise 0.	1/10
Environmental Performance	Key Pollution Monitoring Unit	Company key monitoring unit in the report is assign a value of 0, otherwise 1.	1/3
	Sudden Environmental Accident	Having a sudden major environmental pollution incident is assigned a value of 0, otherwise 1.	1/3
	Passing ISO 14001 Certification	Passing ISO 14001 audit is assigned a value of 1, otherwise 0.	1/3

Table A1. Cont.

References

- 1. Zhao, L.; Chen, L. Research on the Impact of Government Environmental Information Disclosure on Green Total Factor Productivity: Empirical Experience from Chinese Province. *Int. J. Environ. Res. Public Health* **2022**, *19*, 729. [CrossRef] [PubMed]
- Chen, W.; Ting Cho, F. Environmental information disclosure and societal preferences for urban river restoration: Latent class modelling of a discrete-choice experiment. *J. Clean. Prod.* 2019, 231, 1294–1306. [CrossRef]
- 3. Zhu, X.; Zhu, Y.; Meng, X. Government Environmental Information Disclosure and Environmental Performance: Evidence from China. *Sustainability* **2021**, *13*, 6854. [CrossRef]
- Li, Z.; Zhang, T.; Zhao, X.; Zhu, Y. Monitoring or Colluding? Institutional Investors' Heterogeneity and Environmental Information Disclosure Behavior. *Front. Psychol.* 2022, 13, 911901. [CrossRef]
- 5. Pedron, A.; Macagnan, C.; Simon, D.; Vancin, D. Environmental disclosure effects on returns and market value. *Environ. Dev. Sustain.* **2020**, *23*, 4614–4633. [CrossRef]
- 6. Nimanthi, D.; Priyadarshanie, W. Environmental Disclosure Practices and Firm Performance; Evidence from Sri Lanka. *Proc. Int. Conf. Bus. Manag.* **2021**, *17*, 81–94. [CrossRef]
- Hardcopf, R.; Shah, R.; Dhanorkar, S. The Impact of a Spill or Pollution Accident on Firm Environmental Activity: An Empirical Investigation. *Prod. Oper. Manag.* 2021, 30, 2467–2491. [CrossRef]
- Latif, R.; Yahya, N.; Mohd, K.; Kamardin, H.; Ariffin, A. The influence of board diversity on environmental disclosure and sustainability performance in Malaysia. *Int. J. Energy Econ. Policy* 2020, 10, 287–296. [CrossRef]
- 9. Kim, I.; Ryou, J.; Yang, R. The color of shareholders' money: Institutional shareholders' political values and corporate environmental disclosure. J. Corp. Financ. 2020, 64, 101704. [CrossRef]
- 10. Ahmad, N.; Li, H.; Tian, X. Increased firm profitability under a nationwide environmental information disclosure program? Evidence from China. *J. Clean. Prod.* **2019**, 230, 1176–1187. [CrossRef]
- 11. Mrkajic, B.; Murtinu, S.; Scalera, V. Is green the new gold? Venture capital and green entrepreneurship. *Small Bus. Econ.* **2019**, *52*, 929–950. [CrossRef]
- 12. Galbreath, J. Drivers of Green Innovations: The Impact of Export Intensity, Women Leaders, and Absorptive Capacity. *J. Bus. Ethics* **2019**, *158*, 47–61. [CrossRef]

- 13. Kosajan, V.; Chang, M.; Xiong, X.; Feng, Y.; Wang, S. The design and application of a government environmental information disclosure index in China. *J. Clean. Prod.* 2018, 202, 1192–1201. [CrossRef]
- 14. Danisch, C. The Relationship of CSR Performance and Voluntary CSR Disclosure Extent in the German DAX Indices. *Sustainability* **2021**, *13*, 4904. [CrossRef]
- 15. Yang, Y.; Yang, F.; Zhao, X. The impact of the quality of environmental information disclosure on financial performance: The moderating effect of internal and external stakeholders. *Environ. Sci. Pollut. Res.* **2022**, *22*, 20553. [CrossRef]
- 16. Alexopoulos, I.; Kounetas, K.; Tzelepis, D. Environmental and financial performance. Is there a win-win or a win-loss situation? Evidence from the Greek manufacturing. *J. Clean. Prod.* **2018**, 197, 1275–1283. [CrossRef]
- 17. Jiang, Y.; Qin, S.; Xu, Y. Impact of green credit policy on sustainability performance of high-pollution enterprises. *Environ. Sci. Pollut. Res.* **2022**, *22*, 21315. [CrossRef]
- Zhao, A.; Wang, J.; Sun, Z.; Guan, H. Environmental taxes, technology innovation quality and firm performance in China—A test of effects based on the Porter hypothesis. *Econ. Anal. Policy* 2022, 74, 309–325. [CrossRef]
- Wang, X.; Zhang, T.; Nathwani, J.; Yang, F.; Shao, Q. Environmental regulation, technology innovation, and low carbon development: Revisiting the EKC Hypothesis, Porter Hypothesis, and Jevons' Paradox in China's iron & steel industry. *Technol. Forecast. Soc. Change* 2022, 176, 121471. [CrossRef]
- Wu, W.; Ullah, R.; Shah, S. Linking Corporate Environmental Performance to Financial Performance of Pakistani Firms: The Roles
 of Technological capability and Public awareness. Sustainability 2020, 12, 1446. [CrossRef]
- Algarni, M.; Ali, M.; Albort-Morant, G.; Leal-Rodríguez, A.; Latan, H.; Ali, I.; Ullah, S. Make green, live clean! Linking adaptive capability and environmental behavior with financial performance through corporate sustainability performance. *J. Clean. Prod.* 2022, 346, 131156. [CrossRef]
- Chouaibi, S.; Rossi, M.; Siggia, D.; Chouaibi, J. Exploring the Moderating Role of Social and Ethical Practices in the Relationship between Environmental Disclosure and Financial Performance: Evidence from ESG Companies. *Sustainability* 2021, 14, 209. [CrossRef]
- 23. Yin, H.; Li, M.; Ma, Y.; Zhang, Q. The Relationship between Environmental Information Disclosure and Profitability: A Comparison between Different Disclosure Styles. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1556. [CrossRef] [PubMed]
- 24. Jiang, Y.; Guo, C.; Wu, Y. Can environmental information disclosure promote the high-quality development of enterprises? The mediating effect of intellectual capital. *Environ. Sci. Pollut. Res.* **2021**, *28*, 30743–30757. [CrossRef]
- 25. Agyemang, A.; Yusheng, K.; Twum, A.; Ayamba, E.; Kongkuah, M.; Musah, M. Trend and relationship between environmental accounting disclosure and environmental performance for mining companies listed in China. *Environ. Dev. Sustain.* **2021**, 23, 12192–12216. [CrossRef]
- 26. Abdullah, M.; Hamzah, N.; Ali, M.; Tseng, M.; Brander, M. The Southeast Asian haze: The quality of environmental disclosures and firm performance. *J. Clean. Prod.* 2020, 246, 118958. [CrossRef]
- 27. Gupta, H.; Barua, M. A grey DEMATEL-based approach for modeling enablers of green innovation in manufacturing organizations. *Environ. Sci. Pollut. Res.* 2018, 25, 9556–9578. [CrossRef] [PubMed]
- 28. Feng, Y.; Wang, X.; Liang, Z. How does environmental information disclosure affect economic development and haze pollution in Chinese cities? The mediating role of green technology innovation. *Sci. Total Environ.* **2021**, 775, 145811. [CrossRef]
- 29. Lin, S. Can Environmental Information Disclosure Improve Urban Green Economic Efficiency? New Evidence from the Mediating Effects Model. *Front. Environ. Sci.* 2022, 10, 920879. [CrossRef]
- 30. Wu, H.; Qu, Y. How Do Firms Promote Green Innovation through International Mergers and Acquisitions: The Moderating Role of Green Image and Green Subsidy. *Int. J. Environ. Res. Public Health* **2021**, *18*, 7333. [CrossRef]
- 31. Kraus, S.; Rehman, S.; García, F. Corporate social responsibility and environmental performance: The mediating role of environmental strategy and green innovation. *Technol. Forecast. Soc. Change* 2020, *160*, 120262. [CrossRef]
- 32. Mbanyele, W.; Huang, H.; Li, Y.; Muchenje, L.; Wang, F. Corporate social responsibility and green innovation: Evidence from mandatory CSR disclosure laws. *Econ. Lett.* **2022**, *212*, 110322. [CrossRef]
- Du, M.; Chai, S.; Wei, W.; Wang, S.; Li, Z. Will environmental information disclosure affect bank credit decisions and corporate debt financing costs? Evidence from China's heavily polluting industries. *Environ. Sci. Pollut. Res.* 2022, 29, 47661–47672. [CrossRef]
- He, Y.; Ding, X.; Yang, C. Do environmental regulations and financial constraints stimulate corporate technological innovation? Evidence from China. J. Asian Econ. 2021, 72, 101265. [CrossRef]
- Ding, X.; Appolloni, A.; Shahzad, M. Environmental administrative penalty, corporate environmental disclosures and the cost of debt. J. Clean. Prod. 2022, 332, 129919. [CrossRef]
- 36. Luo, W.; Guo, X.; Zhong, S.; Wang, J. Environmental information disclosure quality, media attention and debt financing costs: Evidence from Chinese heavy polluting listed companies. *J. Clean. Prod.* **2019**, 231, 268–277. [CrossRef]
- Zhang, Y.; Xing, C.; Wang, Y. Does green innovation mitigate financing constraints? Evidence from China's private enterprises. J. Clean. Prod. 2020, 264, 121698. [CrossRef]
- Hu, L.; Yang, D. Female Board Directors and Corporate Environmental Investment: A Contingent View. Sustainability 2021, 13, 1975. [CrossRef]
- Nerantzidis, M.; Tzeremes, P.; Koutoupis, A.; Pourgias, A. Exploring the black box: Board gender diversity and corporate social performance. *Financ. Res. Lett.* 2022, 48, 102987. [CrossRef]

- 40. Rjiba, H.; Thavaharan, T. Female representation on boards and carbon emissions: International evidence. *Financ. Res. Lett.* 2022, 49, 103079. [CrossRef]
- Goh, B.; Lim, C.; Lobo, G.; Tong, Y. Conditional Conservatism and Debt versus Equity Financing. *Contemp. Account. Res.* 2016, 34, 216–251. [CrossRef]
- 42. Jackson, A. Dissecting Anomalies with a Five-Factor Model. CFA Dig. 2016, 29, 69–103. [CrossRef]
- 43. García-Granero, E.; Piedra-Muñoz, L.; Galdeano-Gómez, E. Eco-innovation measurement: A review of firm performance indicators. *J. Clean. Prod.* 2018, 191, 304–317. [CrossRef]
- 44. Jain, T.; Zaman, R. When Boards Matter: The Case of Corporate Social Irresponsibility. Br. J. Manag. 2020, 31, 365–386. [CrossRef]
- 45. Cosma, S.; Schwizer, P.; Nobile, L.; Leopizzi, R. Environmental attitude in the board. Who are the "green directors"? Evidences from Italy. *Bus. Strategy Environ.* **2021**, *30*, 3360–3375. [CrossRef]
- Hadlock, C.; Pierce, J. New Evidence on Measuring Financial Constraints: Moving Beyond the KZ Index. *Rev. Financ. Stud.* 2010, 23, 1909–1940. [CrossRef]
- Nylund, P.; Arimany-Serrat, N.; Ferras-Hernandez, X.; Viardot, E.; Boateng, H.; Brem, A. Internal and external financing of innovation. *Eur. J. Innov. Manag.* 2019, 23, 200–213. [CrossRef]
- Wen, Z.; Ye, B. Different methods for testing moderated mediation models: Competitors or backups? *Acta Psychol. Sin.* 2014, 46, 714–726. Available online: https://journal.psych.ac.cn/acps/EN/Y2014/V46/I5/714 (accessed on 15 May 2022). [CrossRef]
- 49. Jin, Z.; Song, S.; Yang, X. The role of female directors in corporate investment in China. *China J. Account. Stud.* **2014**, *2*, 323–344. [CrossRef]
- 50. Igartua, J.; Hayes, A. Mediation, Moderation, and Conditional Process Analysis: Concepts, Computations, and Some Common Confusions. *Span. J. Psychol.* **2021**, 24, E49. [CrossRef]
- 51. Lei, Z.; Huang, L.; Cai, Y. Can environmental tax bring strong porter effect? Evidence from Chinese listed companies. *Environ. Sci. Pollut. Res.* **2022**, *29*, 32246–32260. [CrossRef] [PubMed]
- Zhao, X.; Jia, M. Sincerity or hypocrisy: Can green M&A achieve corporate environmental governance? *Environ. Sci. Pollut. Res.* 2022, 29, 27339–27351. [CrossRef]
- Yang, N.; Liu, Q.; Wang, X. How does industrial coagglomeration affect regional green innovation? Evidence from Chinese cities. *Technol. Anal. Strateg. Manag.* 2022, 2022, 2026319. [CrossRef]
- 54. Zhang, Z.; Duan, H.; Shan, S.; Liu, Q.; Geng, W. The Impact of Green Credit on the Green Innovation Level of Heavy-Polluting Enterprises—Evidence from China. *Int. J. Environ. Res. Public Health* **2022**, *19*, 650. [CrossRef]
- Lagasio, V.; Cucari, N. Corporate governance and environmental social governance disclosure: A meta-analytical review. *Corp. Soc. Responsib. Environ. Manag.* 2019, 26, 701–711. [CrossRef]
- 56. Yang, Z.; Nguyen, T.; Nguyen, H.; Nguyen, T.; Cao, T. Greenwashing Behaviour: Causes, Taxonomy and Consequences Based on a Systematic Literature Review. *J. Bus. Econ. Manag.* **2020**, *21*, 1486–1507. [CrossRef]
- 57. Liu, M.; Liu, L.; Xu, S.; Du, M.; Liu, X.; Zhang, Y. The Influences of Government Subsidies on Performance of New Energy Firms: A Firm Heterogeneity Perspective. *Sustainability* **2019**, *11*, 4518. [CrossRef]