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Impact of Environmental Regulation on Corporate Green Technological Innovation: The Moderating Role of Corporate Governance and Environmental Information Disclosure

Ying Ying and Shanyue Jin *

College of Business, Gachon University, Seongnam 13120, Republic of Korea
* Correspondence: jsyrena0923@gachon.ac.kr

Abstract: Environmental degradation is an important issue facing the world today. Microcosmically, green technical innovation is needed to decrease environmental pollution. Therefore, exploring the relationship between the two is of great significance for promoting environmental protection and sustainable development. Thus, this research elucidates the interaction between green innovation (GI) and environmental regulations (ERs). This study utilizes the fixed effects model to examine how government environmental protection subsidies (EPSs) in market-incentive ER and environmental management system certification (EMSC) in voluntary participatory ER affect GI among listed companies in China. The sample observation period is from 2012 to 2021. Additionally, the impact of corporate governance (CGL) and environmental information disclosure (EID) on the relationship between ERs and GI within businesses is investigated. The empirical results show that both government environmental protection subsidies and environmental management system certification positively affect green innovation, and both corporate governance and environmental information disclosure positively moderate the impact of government environmental protection subsidies and environmental management system certification on green innovation. The above empirical results are still valid after a robustness test and can guide the formulation of government ERs, as well as corporate strategies for environmental management and GI.

Keywords: environmental regulation; government environmental protection subsidies; environmental management system certification; green technology innovation; corporate governance; environmental information disclosure

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1. Introduction

The issue of environmental contamination and the need for balanced and sustainable economic and environmental growth have become more severe. China's economic growth has caused elevated energy usage and environmental contamination [1]. China is ranked 160th in the 2022 Environmental Performance Index (EPI), and the tension between economic expansion and adverse ecological effects is becoming more evident. Addressing environmental pollution requires prioritizing the implementation of effective and suitable environmental regulatory measures to build an ecological civilization.

Environmental regulations (ERs) are an important means of reducing environmental pollution [2]. The public demands that the government introduce appropriate policies to deal with environmental pollution [3], and that companies take up their own corporate social responsibility, increase their environmental investment, and enhance their environmental efficiency [4]. Corporations can mitigate environmental pollution by enhancing production efficiency and upgrading through innovation in green technology [5]. At this point, to assist governments and businesses in resolving environmental issues, it is critical to define the connections between various environmental rules and corporate green technological innovation.

Three categories of environmental regulation are identified by the current study [6]: (1) command–control ER, mainly through administrative penalties for polluters to strengthen environmental protection; (2) market-incentive ER, which reduces environmental pollution primarily by adjusting taxes and financial subsidies to influence the cost and price of products; and (3) voluntary participatory ER, relying mainly on the self-regulation of enterprises to reduce environmental impact. Environmental regulations can squeeze firms' production costs, decreasing their productive capacity [7]. The right environmental regulatory tools can encourage companies to come up with green technologies [8]. Environmental regulations can help businesses use less energy and care for the earth [9], promote green technologies, and bring in more foreign investment [10,11], which can promote the green transformation of industries [12]. Furthermore, there is one curvilinear connection between pollution and the interplay between statutory and informal environmental restrictions [13]. Different kinds of environmental legislation are positively correlated with businesses' environmental responsibility, and this relationship is higher in highly marketed areas and competitive industries [14]. China's ERs used to be based only on administrative orders from the government, but now they include command–control, market-incentive, and volunteer participation environmental rules [9]. Although market-incentivized environmental regulations began later, they are more probable to have a significant and enduring impact. [15]. Enterprises must proactively apply environmental regulations for sustainable development [16].

Corporate governance and environmental information disclosure play increasingly significant roles in corporate environmental management. Chinese corporate governance has strong localization characteristics [17], and examining the influence of corporate governance in the Chinese setting is very significant. At the micro level, as the main mechanism for sustainable development [18], a well-organized corporate governance structure can reduce agency problems and effectively improve corporate social responsibility performance [19]. Companies that are unethical or do not aim for sustainable development may tarnish their reputation and face multiple consequences, such as reduced performance [20,21]. At the same time, good corporate governance can attract capital [22], which impacts the operational efficiency of the organization to some degree, thereby affecting corporate success [23]. A higher level of corporate governance can help companies better achieve their carbon emission targets, thereby reducing environmental pollution [24]. In general, environmental information disclosures can provide investors with information about a company's characteristics, which is an essential resource for investors when making investment choices [25]. Enhanced environmental information disclosure can reduce information imbalances and enhance business investment effectiveness, therefore impacting company earnings [26]. It is worth highlighting that environmental information dissemination can also minimize environmental pollution [27], enhance public concern about the environment [28], enhance the environmental image of businesses [29], and support the advancement of sustainable practices in businesses [30].

Against this background, this study analyzes the impact of EPSs in market-based ER and EMSC in voluntary participatory ER on GI. Meanwhile, it examines how CGL and EID influence the connection between ERs and GI. This study selects China's A-share listed companies from 2012 to 2021 as the research objects. The results show that EPSs and EMSC promote GI. At the same time, both CGL and EID have a positive moderating effect on this positive impact. This study provides a reference for government environmental regulation planning, enterprise environmental management, and enterprise green technology innovation.

The study's contributions are as follows: Firstly, studies have primarily concentrated on the connection between environmental legislation and GI on a broad scale, emphasizing the impact on regional development. By taking a micro-viewpoint, this study advances knowledge regarding how environmental laws affect corporate green initiatives. Secondly, it expands upon previous research by examining the effects of ERs on GI based on the existing literature classification criteria. Finally, it not only expands the application conditions

of CGL and EID but also clarifies the internal environmental conditions of the different types of ER applied to corporate green development. This study further validates Porter's hypothesis and provides references for government environmental regulation planning, corporate environmental management, and green technological innovation.

2. Theoretical Background and Hypotheses

ERs can be categorized into command and control, market incentives, voluntary participation approaches [31–33], formal versus informal environmental regulations [34,35], and other classifications. Various environmental rules utilize distinct environmental regulating tools; for example, emission fees and the promulgation of emission standards are used under command–control environmental regulations [36], and market-incentive environmental rules utilize incentives like tax rebates, environmental subsidies, and emissions trading [37]. Various environmental regulations differ, and failing to account for this diversity may lead to biased research results [38]. There is currently no agreement on how environmental rules affect corporate green technical innovation, with three primary conclusions: promotion [39–43], inhibition [44], and uncertainty [45,46]. Given the maturity of research on the command-and-control model, this study examines the impact of EPSs in market-incentive-type ER and EMSC in voluntary ER on GI, and explores how CGL and EID affect the relationship between the two.

2.1. Market-Incentive ER and GI

In environmental management studies, institutional theory is often considered an external pressure that promotes environmental activities in firms. Institutional theory posits that corporations need to adhere to existing environmental regulations and principles to attain sustainable growth [47]. Green technology innovation drives green economic development and plays a crucial role in environmental management through pollution control [48]. Therefore, enhancing green technological innovation in businesses is a successful strategy for environmental protection and sustainable development [49]. China is developing a policy framework for energy savings and emission reduction by 2030, with a focus on market-incentive ER [50]. When weighed against command-controlled environmental management, this is a more cost-effective choice [51]. ERs with a market incentive can increase the profitability of businesses, encouraging them to invest more in R&D to support GI [52]. They can mitigate cost constraints from environmental rules by enhancing productivity and adjusting production costs flexibly [53]. Given that green technological innovation yields the dual benefits of knowledge spillover and environmental conservation, government backing for firms' green innovation endeavors is essential [54].

EPSs are a crucial type of market incentive for ERs that aim to encourage innovative activities by providing compensation to enterprises engaged in energy conservation [55]. As per the resource-based concept, government subsidies for environmental protection might directly enhance the resources required by enterprises to achieve technological innovation [56], compensate for their environmental costs, and enhance their social reputations [55]. According to research, when green R&D is effective, government environmental protection subsidies are more beneficial to society than environmental taxes and can directly subsidize green investments by companies to reduce environmental damage [57]. Government subsidies for environmental protection can help decrease carbon emissions and encourage the growth of a low-carbon economy [58]. In addition, increased consumer awareness of low-carbon products will favor more environmentally friendly products, and government environmental subsidies will help firms set optimal prices to enhance product competitiveness [59]. Government environmental subsidies can stimulate green technology innovation by compensating for funding shortages, reducing firms' R&D costs, and broadening the range of funding sources [60]. Government subsidies can mitigate commercial risks for firms, and support increases in the number and quality of green technological developments [61]. This study highlights the significance of EPSs in promoting GI in business.

In summary, EPSs can compensate for environmental costs, reduce business risk, broaden financing channels, and reduce environmental damage. Therefore, this study proposes the following hypothesis:

Hypothesis 1. *EPSs have a strong effect on GI.*

2.2. Voluntary Participatory ER and GI

Environmental economics theory asserts that a harmonious balance between the economy and the environment is essential, with environmental preservation being a key objective of economic progress [62,63]. The government's environmental regulation policy has long been predominant in environmental governance, but relying on government power alone has not been sufficient; businesses need to proactively engage in environmental management to lower environmental expenses and advance sustainable growth. Voluntary participatory environmental regulation refers to enterprises independently committing to controlling pollution and protecting the environment [64], offering flexibility and autonomous selectivity for firms [65]. Studies have indicated that voluntary environmental management regulation can increase firms' environmental awareness and that these voluntary measures can reduce pollution through multiple channels [66] as well as increase firms' environmental autonomy [67].

The International Organization for Standardization, Geneva, Switzerland, 2015 (*ISO 14001:2015*) is environmental management systems Requirements with guidance for use. China has had the highest number of ISO 14001-certified companies in the world since 2016 [68]. ISO 14001 specifies the standards that companies should follow to implement effective environmental management [69], and this certification helps companies enhance their social reputation, increase their legitimacy, and reduce damage to the natural environment [70]. Studies have shown that ISO 14001 certification can improve a company's operational efficiency through the greater use of resources and waste management [71]. Moreover, according to signaling theory [72], ISO 14001 certification can help companies gain social prestige, which is beneficial for them in obtaining external financing.

In summary, EMSC can promote operational efficiency, reputation, and access to financing for firms. Thus, we propose the following hypothesis:

Hypothesis 2. *EMSC has a strong effect on GI.*

2.3. Moderating Role of CGL

Based on the triple bottom line theory, a framework for good corporate governance should include economic, social, and environmental factors. CGL is the primary sustainable development mechanism for companies, and it has been shown to improve environmental quality [18]. Healthy corporate governance not only aims to maximize corporate value but also preserves social and environmental interests [73]. In recent years, corporate governance has been increasingly applied to regulate corporate activities, including their social and environmental impact [74]. Research indicates that effective corporate governance can enhance resource allocation within organizations, hence bolstering the formulation of environmental initiatives [75] and enhancing their achievement of sustainable development [76]. The higher the CGL, the more transparent it is in terms of corporate operations, which can avoid risks, reduce costs, improve operational efficiency in a timely manner [23], and be more conducive to corporate green technological innovation [77]. In addition, corporate governance factors like shareholder structure, board structure, and corporate remuneration incentives can influence a company's green technology innovation [78]. Firms' environmental activities are largely subject to policy arrangements related to corporate governance [79]. Businesses with different CGLs take different positions on environmental laws, which may affect how they progress green technology within the company. Analyzing the interplay between GI and ERs at different corporate governance levels is crucial. In summary,

Hypothesis 3. *CGL promotes a strong impact of EPSs on GI.*

Hypothesis 4. *CGL promotes a strong impact of EMSC on GI.*

2.4. Moderating Role of EID

Legitimacy theory asserts the existence of a "social contract" between business and society—the purpose of business is not only to make profits but also to follow the "social contract", and act in a way that is consistent with the social contract and the expectations of stakeholders [80], implying that business actions must be legal [81]. Stakeholder theory suggests that corporations increase their EID in response to the rising environmental expectations of stakeholders to alleviate pressure [82]. Companies often enhance their environmental information sharing to uphold the validity of their activities [83], which is a basic strategy for responding to society as well as stakeholders who act in accordance with the social contract [84]. Research shows that EID can increase the incentives for companies to use clean energy, improve their energy mix, and promote energy use efficiency [85]. Simultaneously, disclosing environmental information can demonstrate a company's commitment to social responsibility and lead to a competitive edge [86]. Furthermore, environmental information disclosure can reduce pollutant emissions, quickly and effectively assess corporate environmental pollution, and positively influence environmental quality [87]. Companies that provide limited environmental information may cause corporate managers to overlook their environmental and sustainability objectives in favor of short-term gains and performance [88]. Thus, we propose the following hypotheses:

Hypothesis 5. *EID promotes the positive impact of EPSs on GI.*

Hypothesis 6. *EID promotes the positive impact of EMSC on GI.*

The research framework is in Figure 1.

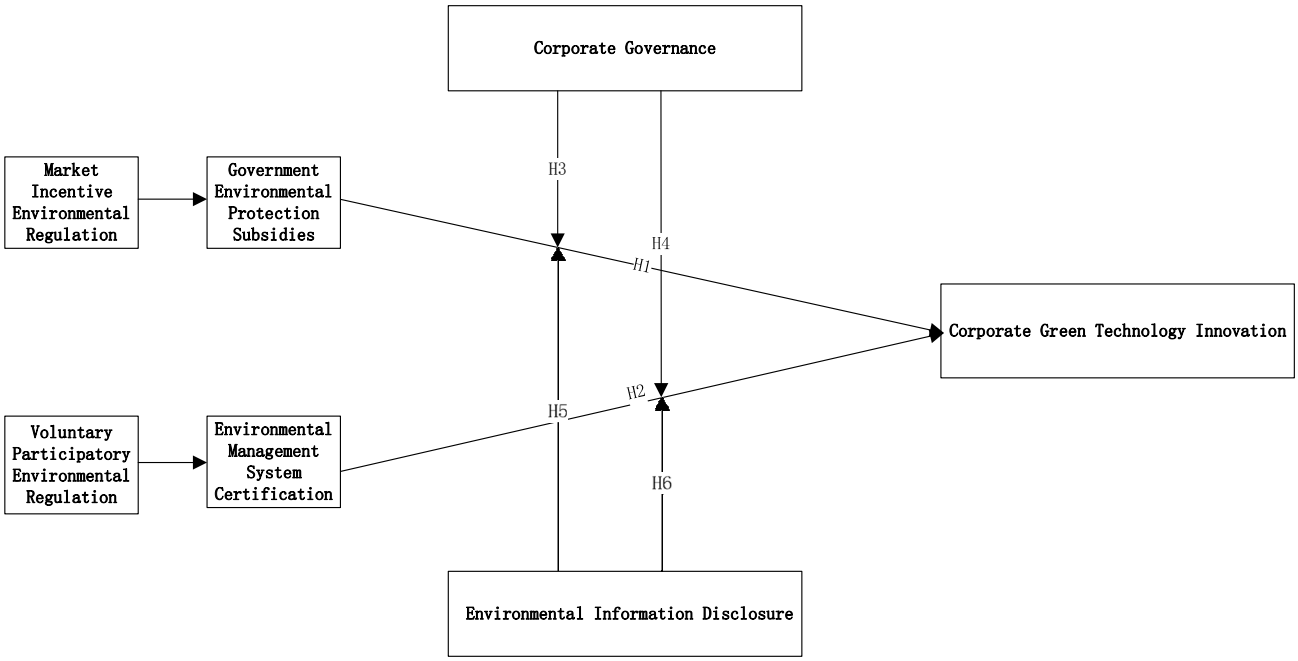

Figure 1. Research framework.

3. Methodology

3.1. Data and Samples

To ensure an adequate sample size, data from the last ten years were selected. This study focused on listed companies in China over the period 2012–2021. It examines how

environmental regulations (ERs) affect green innovation (GI). In reference to existing research [89–91], the data were excluded and processed based on specific criteria: (1) listed financial industry enterprises were excluded; (2) listed companies classified as ST, ST*, and PT due to abnormal financial conditions were omitted from the data; (3) companies exhibiting notable abnormal observations were excluded from the dataset. The study obtained 19,425 sample observations. All continuous variables were put through a 1% tailored process to lessen the effect of outliers. The data used in this study were obtained from the China Stock Market and Accounting Research Database (https://data.csmar.com, accessed on 2 March 2023) and Chinese Research Data Services (https://www.cnrds.com, accessed on 2 March 2023), and the data were processed using Stata 17.0 and SPSS 27.0.

3.2. Variable Definition and Measurement

3.2.1. Dependent Variable

GI: The quantity of patents is a crucial measure of corporate innovation [92]. Referring to existing research [93,94], this study utilizes the logarithm of the number of green patent applications increased by one as a metric for assessing GI. The reason for using the year of application of green patents rather than the year of the grant is that the patent examination process is longer, and the year of application is more representative of the actual time of corporate innovation [95]. For example, the total number of green patent applications of enterprise A in 2013 was N, and the value of its enterprise green technology innovation level in that year was the natural logarithm of N + 1. The total number of enterprises' green patent applications comes from the CSMAR database (https://data.csmar.com, accessed on 2 March 2023).

3.2.2. Independent Variables

EPSs: These funds are allocated by the government to companies to help enhance their environmental performance [96]. EPSs received by companies are disclosed in the notes of their annual reports, including the amount and specific details [97]. With reference to current research [98], this study adopts manual screening by searching the notes to the financial statements of companies' annual reports for the keywords "energy saving," "emission reduction," "pollution control," "environmental protection," "clean," "green," and other such keywords. The government subsidy amounts for all entries are then summed. As government subsidy amounts are exceedingly large, this study logarithms the manually calculated government subsidy amounts [99]. All financial statement data come from the CSMAR database. In order to ensure data quality, this study extracted part of the financial statement data from the database and compared it with the financial statement data from the official website of the enterprise, and the results showed consistency.

EMSC: By using previous research, this study develops a dummy variable [100]. The dummy variable was given a number of 1 if the company obtained certification for ISO 14001, and 0 if the company did not obtain certification for ISO 14001 in the current year. To verify the accuracy of the data, the dummy variables of the environmental management system created in this study were randomly compared with the information in the CNRDS platform.

3.2.3. Moderating Variables

CGL: This system is intricate, comprising different dimensions like board characteristics and shareholding structures. Compared to a single indicator, a composite score constructed from a set of corporate governance indicators or characteristics can more accurately represent the corporate governance standard [101]. This study utilizes principal component analysis to create CGL. With reference to existing studies [102–106], seven indicators were selected for index construction based on three aspects: incentives, decision making, and supervision. The initial principal component derived from principal component analysis served as an indicator of corporate governance level, with a higher value indicating better corporate governance.

EID: Referring to previous studies [26], the revelation of corporate environmental goals in CSMAR data was chosen as a substitute variable for EID. If the company includes its social responsibility or environmental goals in its annual report, it gets a value of 1. If it does not, it gets a value of 0.

3.2.4. Other Variables

Relevant variables that could influence GI, as indicated by previous studies [107–109], were managed to guarantee the precision of the results. The study sets the dummy variable for industry and year, separately. The details of the variables are in Table 1.

Table 1. Variable definition and measurement.

Variables	Symbol	Definitions
Green technological innovation	GI	Logarithm of the amount of GI plus 1
Environmental protection subsidy	EPS	Logarithm of the amount of EPS + 1
Environmental management system certification	EMSC	It is 1 for ISO14001 certified and 0 otherwise
Level of corporate governance	CGL	It is constructed by the PCA method
Environmental information disclosure	EID	It is 1 for disclosing environmental objectives and 0 otherwise
Size of enterprise	Size	Logarithm of total assets
Asset–liability ratio	Lev	Total liabilities/total assets
Net profit margin on total assets	ROA	Net profit/average balance of total assets
Cash flow ratio	Cashflow	Net cash flow from operating activities/total assets
Year of listing	ListAge	Logarithm of the year of listing plus 1
Dummy variable of industry	Industry	Industry membership is 1 and 0 otherwise.
Dummy variable of year	Year	Belonging to the year is 1 and 0 otherwise

3.3. Models

Referring to the existing literature [110], this study uses ordinary least square regression (OLS) to set the model based on panel data. In the six models, $GI_{i,t}$ reflects the firm's level of GI as the explanatory variable in year t. $\Sigma Control_{i,t}$ reflects the general magnitude of the control variables. φ_Y and γ_I show both the industry and the year dummy variables. $\varepsilon_{i,t}$ represents residual terms.

$EPS_{i,t}$ and $EMSC_{i,t}$ are explanatory variables. The former reflects the level of EPSs received by firm i in year t; the greater the value, the greater the amount of government subsidy. The latter reflects the EMSC. If the certification was successful, it is 1; otherwise, it is 0. Models (1) and (2) test the influence of EPSs and EMSC on GI, respectively. In Model (1), if β_1 is positive and passes the significance test, EPSs will have a strong effect on GI; thus, Hypothesis 1 is valid. Similarly, if β_2 is positive and statistically significant, EMSC will have a positive effect on GI; thus, research Hypothesis 2 is valid.

Models (3) to (6) test the moderating effects. In Model (3), $EPS_{i,t} \times CGL_{i,t}$ between government environmental subsidies and corporate governance is added to verify the moderating effect of CGL. If β_2 and β_1 are positive and statistically significant, it indicates that the higher the level of CGL, the stronger the positive effect of EPSs on GI; thus, H3 holds, and Model (4) is the same. In addition, in Model (5), $EPS_{i,t} \times EID_{i,t}$ between EMSC and EID is added to verify the moderating effect of EPSs. If β_2 and β_1 are positive and statistically significant, it means that the higher the EID, the stronger the positive effect of EPSs on GI, and thus Hypothesis 5 holds and Model (6) is the same.

$$GI_{i,t} = \beta_0 + \beta_1 EPS_{i,t} + \Sigma Control_{i,t} + \varphi_Y + \gamma_I + \varepsilon_{i,t} \quad (1)$$

$$GI_{i,t} = \beta_0 + \beta_1 EMSC_{i,t} + \Sigma Control_{i,t} + \varphi_Y + \gamma_I + \varepsilon_{i,t} \quad (2)$$

$$GI_{i,t} = \beta_0 + \beta_1 EPS_{i,t} + \beta_2 EPS_{i,t} \times CGL_{i,t} + \beta_3 CGL_{i,t} + \Sigma Control_{i,t} + \varphi_Y + \gamma_I + \varepsilon_{i,t} \quad (3)$$

$$GI_{i,t} = \beta_0 + \beta_1 EMSC_{i,t} + \beta_2 EMSC_{i,t} \times CGL_{i,t} + \beta_3 CGL_{i,t} + \Sigma Control_{i,t} + \varphi_Y + \gamma_I + \varepsilon_{i,t} \quad (4)$$

$$GI_{i,t} = \beta_0 + \beta_1 EPS_{i,t} + \beta_2 EPS_{i,t} \times EID_{i,t} + \beta_3 EID_{i,t} + \Sigma Control_{i,t} + \varphi_Y + \gamma_I + \varepsilon_{i,t} \quad (5)$$

$$GI_{i,t} = \beta_0 + \beta_1 EMSC_{i,t} + \beta_2 EMSC_{i,t} \times EID_{i,t} + \beta_3 EID_{i,t} + \Sigma Control_{i,t} + \varphi_Y + \gamma_I + \varepsilon_{i,t} \quad (6)$$

4. Results

4.1. Descriptive Statistics

In Table 2, the mean of GI is 0.44 and the standard deviation (SD) is 0.702, which suggests a significant disparity in GI among enterprises. The mean of EPSs is 3.70 and the SD is 6.014, which indicates that the amount of EPSs by different enterprises varies. Their maximum value is 17.145 and their minimum value is 0.000, which indicates that some have never received EPSs, and others have received EPSs. The mean value of EMSC is 0.21, the SD is 0.404, and the median is 0.000, indicating that certified samples of the enterprise environmental management system are fewer than the uncertified samples. EID has a mean of 0.82, an SD of 0.385, and a median of 1.000, indicating that companies tend to disclose their environmental protection objectives and that the degree of EID by businesses does not vary much. The mean CGL is 0.10 and the SD is 0.988, showing a significant variation in the degree of corporate governance across businesses. All data met the criteria for a normal distribution, with good data patterns, skewness, and kurtosis.

Table 2. Descriptive statistics.

Variables	N	Mean	SD	Min	Median	Max	Skewness	Kurtosis
GI	19425	0.44	0.702	0.000	0.000	4.094	1.5017	4.4938
EPS	19425	3.70	6.014	0.000	0.000	17.145	1.0727	2.2798
EMSC	19425	0.21	0.404	0.000	0.000	1.000	1.4580	3.1258
EID	19425	0.82	0.385	0.000	1.000	1.000	−1.6606	3.7577
CGL	19425	0.10	0.988	−2.099	0.009	2.401	0.2767	2.3975
Size	19425	22.04	1.208	19.525	21.882	26.430	0.7350	3.6194
Lev	19425	0.41	0.205	0.035	0.393	0.925	0.3049	2.2889
ROA	19425	0.04	0.055	−0.117	0.041	0.182	−0.2164	4.3430
Cashflow	19425	0.04	0.068	−0.197	0.045	0.257	−0.0865	3.9392
ListAge	19425	2.00	0.917	0.000	2.079	3.367	−0.6147	2.4428

4.2. Correlation Analysis

This study analyzed the correlation between all variables using Pearson's correlation coefficient in Table 3. The correlation coefficient (CC) between EPSs and GI is 0.035. This suggests a preliminary positive correlation between EPSs and GI without considering other variables. Similarly, the CC between EMSC and GI is 0.173, which shows a positive correlation. The variance inflation factor was below 3, showing the absence of multicollinearity.

Table 3. Correlation.

	GI	EPS	EMSC	EID	CGL	Size	Lev	ROA	Cashflow	ListAge
GI	1									
EPS	0.035 ***	1								
EMSC	0.173 ***	0.066 ***	1							
EID	0.144 ***	0.081 ***	0.177 ***	1						
CGL	0.059 ***	−0.137 ***	0.001	0.049 ***	1					
Size	0.112 ***	0.130 ***	−0.020 ***	0.047 ***	−0.477 ***	1				
Lev	0.034 ***	0.108 ***	−0.047 ***	−0.038 ***	−0.320 ***	0.518 ***	1			
ROA	0.052 ***	−0.074 ***	0.029 ***	0.016 **	0.092 ***	−0.064 ***	−0.414 ***	1		
Cashflow	0.00700	0.044 ***	0.060 ***	0.042 ***	−0.068 ***	0.056 ***	−0.169 ***	0.407 ***	1	
ListAge	−0.141 ***	0.141 ***	−0.022 ***	−0.042 ***	−0.495 ***	0.426 ***	0.389 ***	−0.314 ***	−0.025 ***	1

Note: *** $p < 0.01$, ** $p < 0.05$.

4.3. Regression Results

The Hausman test results showed that the fixed effects (FE) model should be applied.

In Table 4, as indicated in the first column, the coefficient of EPSs is 0.0029 and satisfies the significance examination, which shows that EPSs have a strong effect on GI; thus, H1 is correct. The coefficient of EMCS is 0.0547 and satisfies the significance examination. This means that EMSC positively promotes GI; thus, H2 holds.

Table 4. Regression Results.

Variables	(1) GI	(2) GI	(3) GI	(4) GI	(5) GI	(6) GI
EPS	0.0029 ***		0.0031 ***	0.0026 ***		
	(3.4005)		(3.6180)	(3.1261)		
EMSC		0.0547 ***			0.0556 ***	0.0423 ***
		(4.0125)			(4.0749)	(2.9080)
CGL			0.0208 **		0.0216 **	
			(2.1149)		(2.1943)	
EID				0.0299 **		0.0376 ***
				(2.5270)		(2.8224)
EPS × CGL			0.0016 *			
			(1.8811)			
EPS × EID				0.0051 ***		
				(2.7294)		
EMSC × CGL					0.0248 *	
					(1.8598)	
EMSC × EID						0.0896 **
						(2.1364)
Size	0.0480 ***	0.0506 ***	0.0504 ***	0.0483 ***	0.0525 ***	0.0503 ***
Lev	−0.0693	−0.0684	−0.0680	−0.0679	−0.0672	−0.0670
	(−1.5758)	(−1.5544)	(−1.5469)	(−1.5432)	(−1.5278)	(−1.5224)
ROA	0.0587	0.0497	0.0717	0.0581	0.0655	0.0555
	(0.5647)	(0.4781)	(0.6891)	(0.5592)	(0.6296)	(0.5345)
Cashflow	−0.1259 *	−0.1293 *	−0.1277 *	−0.1245 *	−0.1298 *	−0.1289 *
	(−1.7915)	(−1.8411)	(−1.8182)	(−1.7731)	(−1.8486)	(−1.8353)
ListAge	−0.0316 **	−0.0341 **	−0.0253	−0.0308 *	−0.0287 *	−0.0335 **
	(−1.9731)	(−2.1248)	(−1.5512)	(−1.9248)	(−1.7579)	(−2.0904)
Constant	−0.5856 **	−0.6396 **	−0.6510 **	−0.6145 **	−0.6914 **	−0.6656 **
	(−2.1038)	(−2.2987)	(−2.3270)	(−2.2073)	(−2.4721)	(−2.3916)
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	19,425	19,425	19,425	19,425	19,425	19,425
R-squared	0.053	0.053	0.053	0.054	0.054	0.131

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

The regression model incorporates the interaction term (EPS × CGL) in Table 4. The results reveal that the coefficient of EPS × CGL is 0.0016 and satisfies the significance examination, while the coefficient of EPSs is significantly optimistic. This indicates that CGL promotes the positive impact of EPSs on GI and exerts a beneficial moderating influence; thus, H3 holds. Similarly, the coefficient of EMSC × CGL is significantly positive, while the coefficient of EMSC is 0.0556, indicating that the higher the CGL, the stronger the impact of EMSC on GI; thus, H4 is valid. In summary, the moderating effect of CGL is verified.

Table 4's fourth column displays how EID moderates the impact of EPSs on GI. The results suggest that the coefficient of EPS × EID is 0.0051 and statistically significant, while the coefficient of EPSs is significantly positive, showing that EID enhances the impact of EPSs on GI; thus, H5 holds. Similarly, Hypothesis 6 is verified.

4.4. Robustness Test

The regression analysis showed that EPSs and EMSC both encourage GI. Higher levels of GI can help companies secure more EPSs and make it easier for them to obtain EMSC. Therefore, a bidirectional causal relationship may exist between the explanatory and explained variables. To ensure the strength and reliability of the research findings, this study constructed instrumental variables (IVs) to address endogeneity and applied the two-stage least squares method (2SLS) to revalidate the research findings. It used one-period lagged EPS and EMSC as IVs for EPSs and EMSC, respectively, and applied the 2SLS method for validation.

The coefficient of EPSt-1 in the first column of Table 5 is 0.1068 and statistically significant. The Cragg–Donald Wald F statistic is 130.295, and the *p*-value is 0.000, using the EPSs in the lagged period and EPSs in the current period as the explained and explanatory variables, respectively, confirming that the IVs passed both the weak IV test and the unidentifiable test. Then, the calculated fitted values are used as the explanatory variables in the second stage and substituted into the second column of the model in Table 5, which shows that the coefficient of EPSs is 0.0185 and satisfies the significance examination, indicating that EPSs still positively contribute to GI after the first stage of fitting. Thus,

H1 holds after solving the endogeneity problem. As shown in Table 5's third and fourth columns, EMSC improves GI, supporting Hypothesis 2.

Table 5. Robustness test.

Variables	First Stage EPS	Second Stage GI	First Stage EMSC	Second Stage GI
EPS_{t-1}	0.1068 *** (11.4147)			
EPS		0.0185 ** (1.9973)		
$EMSC_{t-1}$			0.2175 *** (23.1490)	
EMSC				0.1361 * (1.7776)
Size	0.4944 *** (3.8381)	0.0403 *** (2.7603)	−0.0163 ** (−2.1436)	0.0533 *** (3.9308)
Lev	−0.3937 (−0.7879)	−0.1160 ** (−2.1858)	0.0208 (0.7043)	−0.1261 ** (−2.4082)
ROA	−3.7397 *** (−3.2738)	0.0154 (0.1218)	−0.0343 (−0.5079)	−0.0546 (−0.4564)
Cashflow	0.5154 (0.6606)	−0.0845 (−1.0211)	0.0532 (1.1526)	−0.0819 (−1.0009)
Constant	−10.6306 *** (−3.4361)		0.5497 *** (3.0070)	
Industry FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	13962	13962	13962	13962
R-squared	0.040	0.025	0.057	0.045
Cragg–Donald Wald F statistic	130.295		535.877	
Underidentification test *p*-value	0.000		0.000	
Sargan statistic	0.000		0.000	

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

5. Discussion

Environmental problems such as environmental pollution and greenhouse gas emissions are huge problems facing the world today. Improving the level of green technology innovation in enterprises and developing a carbon-free economy are important ways to improve environmental issues [111]. As an important means for the government to deal with environmental problems, environmental regulation has attracted much academic attention for its impact on enterprises' green technology innovation [112–114].

This study found that appropriate environmental regulatory measures can effectively promote green technology innovation. Few scholars have conducted in-depth discussions on the impact mechanisms of government environmental protection subsidies and enterprises' green innovation. To further clarify the relationship between the two, this study analyzed the impact of government environmental protection subsidies on enterprises' green technology innovation based on institutional theory, environmental economics theory, and triple bottom line theory. As effective government policy tools, government environmental protection subsidies and environmental management system certification have a positive impact on enterprises' green technology innovation, which further validates Porter's hypothesis [115]. Government environmental protection subsidies can compensate enterprises for the costs of green innovation, such as research and development costs, pollution control costs, etc., and have a positive incentive effect on enterprises' green innovation [116]. For enterprises to carry out green innovation activities, a large amount of financial support is essential. Through environmental protection subsidies, the government supports enterprises in carrying out high-quality green innovation R&D activities, reducing green technology spillover, improving green innovation quality and efficiency, and solving the externality problem of green innovation [117,118]. All this evidence supports the hypothesis proposed in this study. That is, government environmental protection subsidies can promote enterprises' green technology innovation.

In addition, this study found that environmental management system certification has a positive impact on enterprises' green technology innovation. In the existing studies, there is no consensus on the impact of environmental management system certification as a voluntary environmental regulation tool on enterprises' green innovation. Some researchers have discussed the impact of voluntary environmental regulation on urban innovation from a macro level and found that the impact is

negative [119]. The relationship between voluntary environmental regulation and enterprise green technology innovation is complex, and there is a lack of research in this field. This study chooses environmental management system certification as the representative of voluntary environmental regulation and studies the relationship between the two at the micro level. Environmental management system certification can improve the quantity and quality of green technologies, minimize the negative impact on production activities, and encourage other stakeholders to actively fulfill their environmental obligations and improve the competitiveness of their products [120]. The empirical analysis also proves that environmental management system certification has a positive impact on enterprise technological innovation.

When discussing the impact of environmental regulation on enterprises' green technology innovation, the regulatory role of corporate governance structure and environmental information disclosure mechanisms cannot be ignored. A good corporate governance structure can ensure the effective use of subsidy funds, reduce the abuse of funds, and avoid shortsighted behaviors, thus promoting the in-depth development of green technology innovation activities [121]. In addition, good corporate governance can alleviate agency problems, motivate managers to pay attention to the long-term development of enterprises, and encourage enterprises to increase R&D investment [122]. Environmental information disclosure is an important way for enterprises to convey their environmental protection concepts and practical actions to the outside world. Through timely, accurate, and comprehensive disclosure of environmental information, enterprises can enhance trust and communication with stakeholders and reduce the negative impact of information asymmetry [123,124]. At the same time, environmental information disclosure can also enhance the reputation and image of enterprises, attract more investors and partners, and create a more favorable external environment for green technology innovation [125]. In addition, environmental information disclosure can motivate enterprises to change their production mode and improve their production efficiency [126]. This research also confirms that government environmental protection subsidies and environmental information disclosure have a significant positive impact on the process of environmental regulation, enabling enterprises to innovate in green technologies.

6. Conclusions and Implications

6.1. Implications

6.1.1. Theoretical Aspect

First, this study examines how corporate GI is affected by voluntary involvement in ER and market-driven ER. It shows that ER promotes GI, which further supports Porter's hypothesis and extends the research on Porter's theory of ER. Second, this research finds that EPSs and EMSC positively promote GI, which clarifies the impact of ERs on GI, and further expands the previous research on corporate green technological innovation. Third, prior research has primarily examined the direct impacts of EID and CGL, with little attention paid to the combined indirect effects. This study examines the limitations of applying ERs to GI in corporate, explores the conditions for applying CGL and EID, and specifies the internal environmental requirements for the effective implementation of ERs on GI.

6.1.2. Practical Aspects

For the government, the findings verify the accuracy of environmental management-related policies, show that appropriate government environmental regulation instruments may assist enterprises in developing and improving green innovation, and provide a reference for further environmental management planning. Enterprises should insist on cooperating with external environmental regulation instruments, strive for government environmental subsidies, and use them to improve their green development. Alternatively, they should endeavor to improve their own environmental regulation level, and actively carry out ISO 14001 to help their own green development. It shows the importance of CGL and EID, serving as a guide for strategic corporate green planning.

6.2. Conclusions

Firstly, the research results show that government environmental protection subsidies are positively promoting enterprises' green technology innovation. With the increase in government environmental protection subsidies, enterprises have more funds and resources to invest in the research, development, and innovation of green technology and thus improve the level of green technology innovation. This reflects the direct role of government subsidies in promoting enterprises' green technology innovation. Secondly, it was found that environmental management system

certification has a positive impact on enterprises' green technology innovation. If an enterprise obtains the environmental management system (ISO 14001) certification, this will help to improve the level of green technology innovation. The environmental management system certification is the embodiment of the enterprise's environmental management ability and environmental responsibility. Obtaining this certification means that the enterprise has a higher management level and professional quality in environmental protection, which helps to encourage the enterprise to carry out green technology innovation activities and improve the level of green technology innovation. Thirdly, the study found that corporate governance positively regulates the positive impact of environmental regulations on green technology innovation. When the level of corporate governance is higher, the positive impact of government environmental protection subsidies and enterprise environmental management system certification on enterprise green technology innovation is more significant. This is because a good corporate governance mechanism can ensure the scientific and effective decision making of enterprises, so that enterprises can better transform these resources into actual results of green technology innovation after receiving government environmental protection subsidies and obtaining environmental management system certification. Finally, the study found that the level of environmental information disclosure by enterprises also positively influences the positive effect of environmental regulation on enterprises' green technology innovation. When enterprises actively disclose their environmental protection information and green technology innovation results, this can not only enhance their social image and reputation but also attract more external resources and support so as to further promote their green technology innovation activities.

6.3. Restrictions and Upcoming Studies

Due to the unique situation and the significant influence of government policies on business operations in China, the conclusions drawn on environmental regulation may only be applicable to listed enterprises in the Chinese context, and may not be applicable to non-listed enterprises in China or enterprises in other areas. Future research is needed to verify the consistency of the findings using a sample of various types of enterprises in different countries and regions. Second, this study only looks at how GI is affected by EPSs in market-based ER and EMSC in voluntary participation ER. However, there are various types of ERs. These instruments may have heterogeneous impacts; hence, only exploring EPSs and EMSC is far from sufficient. In the future, more ER strategies can be thoroughly investigated. Finally, this study considers CGL and EID as boundary conditions to explore their moderating effects but does not investigate how ERs affect GI. This mechanism outlines the impact of ERs on GI and emphasizes the necessity of further research.

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