frontiers | Frontiers in Environmental Science

ORIGINAL RESEARCH
published: 01 June 2022
doi: 10.3389/fenvs.2022.926896

Cultivation Mechanism of Green Technology Innovation in Manufacturing Enterprises Under Environmental Regulations in China

Tong-Jian Zhang[1], *Jian-Ya Zhou*[1], *Min Wang*[1], *Kai Ren*[1], *Muhammad Imran*[2]* *and Rongyu Wang*[2]

[1]School of Management, Jiangsu University, Zhenjiang, China, [2]Information Research Institute, Qilu University of Technology (Shandong Academy of Sciences), Jinan, China

The rapid development of China's economy is increasing the pressure on the country's ecological environment. As the largest developing country in the world, China's environmental crisis is bound to cause global ecological risks. Therefore, green technology innovation is imperative for sustainable development as manufacturing enterprises are heavily affected by the Chinese environment. Through green technology, innovation to help China get rid of the environmental crisis, and then achieve new breakthroughs in the global economy. The Porter hypothesis notes that environmental regulation can promote the growth of green technology innovation capabilities, although the effects have not entirely been felt by China's manufacturing enterprises. This study is based on the structural equation model and considers a sample of China's manufacturing enterprises to empirically test the promotion mechanism of environmental regulation underlying green technology innovation capability. Command-based environmental regulation has the strongest effect on promoting green technology innovation capability, followed by incentive-based environmental regulation. Voluntary environmental regulation has the weakest effect. Green product innovation capability has been well cultivated in the field of green technology innovation capability, followed by green process innovation capability. Terminal technology governance capability is the least developed.

Keywords: environmental regulation, green technology innovation, manufacturing enterprises, Porter hypothesis, 'three wastes' treatment

OPEN ACCESS

Edited by:
Cem Işık,
Anadolu University, Turkey

Reviewed by:
Xin Nie,
Guangxi University, China

***Correspondence:**
Muhammad Imran
imran@sdas.org

Specialty section:
This article was submitted to Environmental Economics and Management, a section of the journal Frontiers in Environmental Science

Received: *23 April 2022*
Accepted: *13 May 2022*
Published: *01 June 2022*

Citation:
Zhang T-J, Zhou J-Y, Wang M, Ren K, Imran M and Wang R (2022) Cultivation Mechanism of Green Technology Innovation in Manufacturing Enterprises Under Environmental Regulations in China. Front. Environ. Sci. 10:926896. doi: 10.3389/fenvs.2022.926896

1 INTRODUCTION

In 2019, the World Economic Forum in Davos stated in its Global Risk Report that five of the top ten risks that the world is currently facing are environmental. The organization believes that environmental risk is the biggest risk worldwide, although it has received insufficient attention so far (Zhang et al., 2020). Ecological risks, which increasingly hinder economic and social development, are also overlooked in China. Cai et al. (2020) have stated that achieving a balance between economic growth and ecological risk prevention is a serious challenge for China moving forward. In the economic globalization system, China's economic status is rising, and its environmental problems attract the attention of the world. The ecological fragility means

China's environmental crisis may evolve into the risk of global ecological collapse. The fifth United Nations Environmental Conference emphasized the sustainable development capacity as the focus of environmental protection, and China's ecological crisis can realize the symbiosis of environment and economy with the help of this capacity.

The manufacturing industry is a pillar of the national economy and comprises many high-polluting industries. Therefore, the development and deepening of green technology innovation in manufacturing enterprises is at the core of China's green technology innovation strategy, which involves environmental protection and ecological governance. Advances in green manufacturing technology innovation will greatly improve China's green technology innovation capability and ecological development and lead to the simultaneous development of the environment and economy.

In 1994, Brawn and Wield first proposed that green technology reduce environmental pollution and resource consumption and improve ecological conditions (Chen et al., 2018). Among the eight new technologies currently supported by China, "resources and environmental technologies" and "new energy and energy-saving technologies" are classified under green technologies. However, green technology is not limited to the high-tech category, as it exists across all industries.

Green technological innovation integrates "green", "technology", and "innovation". It conforms to the development of a green economy and complies with environmental protection laws and regulations. After Schumpeter proposed the concept of technological innovation in 1912, subsequent researchers found that technological innovation plays a double-edged role in environmental protection and pollution. They advocated that all technological innovations that can eliminate negative environmental externalities are green technology innovations. At the beginning of this century, the European Commission defined green technological innovation as the sum of technologies, processes, and products that can minimize negative ecological effects (Mensah et al., 2019). Lv et al. (2021) believed that the significance of green technological innovation is reflected in both green development and technological innovation in seeking the coordinated development of economy and ecology.

In 1995, Professor Porter of the Harvard Business School indicated that, in the long run, government environmental regulations can promote enterprises' technological innovation, offset environmental regulation costs, and enable enterprises to gain core competitive advantages (Porter and Van der Linde, 1995). Government regulations are designed to maximize the public interest, and businesses also benefit from it (Ramanathan et al., 2017). In the past 2 decades, the relationship between environmental regulation, technological innovation, and economic growth has always been in focus in the field of economics under the guidance of the Porter hypothesis (Nie et al., 2021a; Nie et al., 2021b; Nie et al., 2022). The Porter hypothesis can be traced to Hicks, who proposed that changes in the relative prices of factors could induce technological innovation and restrain the economic form (Hicks, 1963). Appropriate environmental regulations are conducive to the improvement of enterprises' innovation ability, but a more relaxed or stricter regulatory environment damages their production enthusiasm (Jiang and Lyu, 2021). Fair environmental regulation has promoting effect on the improvement of enterprise financial performance and promotes the development of ecological innovation (He et al., 2022). Ecological innovation can help enterprises reduce carbon emissions (Fethi and Rahuma, 2020). Environmental regulation should balance pollution prevention and economic growth (Zhang et al., 2022). Zhao et al. (2022) investigated the nonlinear relationship between environmental regulation and green economic growth using a spatial econometric model. They found that environmental regulation can promote the realization of technological innovation by driving economic growth. The spillover effect of the policy will drive the extension of technological innovation (Herman and Xiang, 2019). Environmental regulation can promote the realization of capital accumulation and form subsidies to technological innovation (De Santis et al., 2021; Lu et al., 2021; Ren et al., 2022). The government's tax incentives and subsidies can effectively support enterprises' green innovation activities (Song et al., 2022). Chen et al. (2022) analyzed panel data from 281 prefecture-level cities in China and found that environmental regulation promoted green technology innovation in enterprises, which was consistent with the Porter hypothesis.

Green technological innovation under environmental regulations have attracted the attention of researchers worldwide. Liu and Zhao (2012) stated that under environmental regulations, enterprises should try their best to fulfil environmental protection requirements and ensure long-term development by vigorously expanding green technological innovation. Technological improvements lead to the evolution of social institutions (Işık, 2013). Li (2017) indicated that environmental regulations, including pollution taxes, environmental subsidies, and emission rights trading can improve enterprises' green technology innovation. Zhang and Wu (2017) analyzed the dynamic evolution trajectory of coal enterprises' green technological innovation under environmental regulations and found that environmental regulations can provide institutional guarantees for the advancement of such innovation. Işık et al. (2019a) argue that the use of fossil fuels promotes carbon dioxide emissions. Dong et al. (2020) studied the promotion effect of environmental regulations on green technology innovation by combining provincial data in China and found that the ripple effect of environmental regulations drives technological innovation between industrial neighbors. Environmental regulation forces enterprises to adjust their industrial structure and upgrade their technologies (Wang and Zhang, 2022), which is not possible with other measures. Using the three-party evolutionary game model, Li and Gao (2022) found that the government's punishment of enterprises exceeds the influence of subsidies under environmental regulations. They also found that an increase in enterprises' green research and development investment reduces the technology introduction frequency.

Existing research has shown that the promotion effect of environmental regulation on green technology innovation in China is flawed. Wang and Liu (2019) explained that

environmental regulations can theoretically promote the progress of green technological innovation; however, the actual effects are not obvious because of China's flawed legal system. Wei and Zhang (2020) stated that China's environmental regulations lack experience in implementation and fail to effectively adapt to ecological and environmental protection needs; hence, there is a need for optimization of regulations. Based on Chinese provincial panel data, Ouyang et al. (2020) found that the development of environmental regulations in China is uneven, as various regulatory methods have not yet matured. However, there is still immense potential to drive green technological innovation. Environmental regulations, as regulations introduced by the government, are conducive to the development of technological innovation (Niebel, 2021). Various environmental regulations affect technological innovation differently (Jiang et al., 2021). Based on panel data for Chinese cities, Liu et al. (2021) found that command-based environmental regulation inhibited industrial growth, whereas the role of incentive-based environmental regulation was not remarkable. Through the analysis of enterprise data, Zhang (2022) demonstrated that product quality reduction by heavily polluting enterprises is a response to the green technology requirements under environmental regulation.

The literature has also explored the promotion effect of government environmental regulations on enterprises' green technological innovation and affirmed their value in promoting innovation. However, existing studies have not yet analyzed the internal mechanisms of environmental regulation to promote Chinese enterprises' green technology innovation capability. In addition, the advantages and disadvantages of government environmental regulation have not been assessed at the micro-level. A clear improvement scheme and optimization path have not been proposed. Existing research also lacks focus on the cultivation of green technological innovation in the manufacturing industry under environmental regulations and fails to recognize that manufacturing enterprises form the core of green technological innovation. Accordingly, this study explores the micro-mechanism and path of green technology innovation cultivation of Chinese manufacturing enterprises under environmental regulation and clarifies its directions.

The significance of this study lies in its implications for the development of green technology innovation in China's manufacturing enterprises and improvement of Chinese environmental regulations, as well as its guidance to the world environmental protection. With the help of green technology innovation capacity, China's ecological crisis can be partially alleviated, which has also played a role in easing the world environmental crisis. Compared with the governance approaches of developed countries, China's experience in environmental regulation development is more suitable for developing countries. To achieve deeper environmental protection with limited resources and realize the ecological governance of developing countries means that the universality of this method can help more countries to achieve their own sustainable development, and then realize the improvement of the global ecological environment.

As an important means of exploring sustainable development path in China, the effectiveness of environmental regulation has been tested, but its potential has not been fully developed. The contributions of this paper are summarized as follows: First, a new research perspective is presented. This paper verifies the effect of different types of environmental regulation on the cultivation of the green technology innovation in manufacturing industry with the help of structural equation model. Secondly, this paper analyzes the micro mechanism of the cultivation of green technology innovation in enterprises under environmental regulation, which lays a theoretical foundation for the subsequent policies proposal. Thirdly, this paper expands the analysis framework of environmental regulation and contributes to the improvement of environmental regulations in China. Finally, this paper highlights the specific strategies of government environmental regulation to cultivate the green technology innovation capability of enterprises, which contributes to the improvement of the ecological environment, provides a new road for the global ecological governance, and thus guides the direction for alleviating the world environmental pollution.

The remainder of this paper is structured as follows: **Section 2** introduces the research model design, including the structural analysis of basic elements and the relevant research hypotheses. **Section 3** establishes the structural equation model to verify the research hypothesis, including the establishment of the questionnaire index system, collection of data, and results of model testing. Finally, **Section 4** provides policy recommendations based on the research model conclusions.

2 DEVELOPMENT OF RESEARCH HYPOTHESIS

2.1 Analysis of Basic Element Structure

This study aims to explore the micro-level promotion mechanism of environmental regulation on the elements of green technology innovation. The analysis of the basic structure of government environmental regulations and green technology innovation of manufacturing enterprises is necessary in this regard.

This study divides environmental regulations into three elements: command-based, incentive-based, and voluntary environmental regulations. Under command-based environmental regulations, the government sets clear standards for the technical specifications and pollutant emission intensities of enterprises. In incentive-based environmental regulation, the government encourages green technological innovation through environmental protection taxes, special support funds for cleaner production, trading licenses, and pollution control subsidies. Voluntary environmental regulations imply that enterprises restrict their uncontrolled environmental behaviors by disclosing environmental information, obtaining environmental certification, and marking competitive environment (Li et al., 2018).

The green technology innovation capability of enterprises is divided into three elements: green product innovation, green

process innovation, and terminal technology governance capabilities. Green product innovation capability indicates that enterprises' products are beneficial for the physical and mental health of consumers and environmental protection. Green process innovation capability asserts itself through process design that significantly meets the requirements of environmental protection. Finally, terminal technology governance capability indicates that enterprises meet environmental protection standards through the "three wastes" treatment (Song et al., 2020).

2.2 The Effect of Command-Based Environmental Regulation

Command-based environmental regulation stimulates enterprises' green technology innovation through the formulation and implementation of green emission and green technology standards. This regulation is a strict mandate from the government that enterprises must comply with unconditionally to avoid being penalized by the government. Therefore, enterprises need to continuously intensify green technology innovation and meet the government's emission and technical standards (Li, 2019). When the government sets green emission standards, enterprises should not only improve their terminal technology governance capability *via* "three wastes" but also improve the innovation capability of green products and processes from the source to develop green technology innovation as a whole. When the government sets green technology standards, enterprises should vigorously promote product design, optimize technological processes, and eliminate obsolete equipment to meet the government's technical needs (Wang et al., 2018; Saud et al., 2019). For some products, the government can directly formulate environmental protection standards for product performance and green production. Emission, technical, and environmental protection standards naturally differ for various manufacturing industries. Command-based environmental regulation reflects the government's intervention in the production process of enterprises, indicating that the government can grasp the environmental regulation according to local conditions and urge enterprises to make timely technological adjustment. To meet the requirements of the government, enterprises need to invest resources to improve their green innovation capability, or they will be punished by the government. It is this coercive force that reduces speculation in environmental protection and promotes the process of green production.

Based on the above analysis, this study proposes the following research hypotheses.

H1a: Command-based environmental regulation can enhance manufacturing enterprises' green product innovation capability.

H1b: Command-based environmental regulation can enhance manufacturing enterprises' green process innovation capability.

H1c: Command-based environmental regulation can enhance manufacturing enterprises' terminal technology governance capability.

2.3 The Effect of Incentive-Based Environmental Regulations

Incentive-based environmental regulation is realized through environmental protection taxes, green government subsidies, and emission permit trading. These regulations do not require enterprises to achieve a high level of green technology innovation but can provide incentives for its implementation. If the government increases the collection of environmental protection taxes, companies will try to improve production processes, reduce harmful emissions, and improve environmental protection to avoid paying environmental protection taxes (Deng and Chen, 2020). When the government increases green subsidies, enterprises have more funds and resources to invest in green technology development, which naturally enhances green product innovation, green process innovation, and terminal technology governance capabilities (Saud et al., 2019; Lin et al., 2020). The direct purpose of pollutant discharge permits is to reduce the "three wastes" emissions of enterprises, whereas the indirect purpose is to advance the enterprises' green technological innovation. Incentive-based environmental regulation undoubtedly promotes green technological innovation; however, the micro-mechanism is still unclear. When enterprises invest resources to improve their green innovation capability, it damages their own benefits. Incentive-based environmental regulation can reduce enterprises' investment in this aspect, and then enhance enterprises' enthusiasm. In order to obtain more environmental subsidies, enterprises will increase the use of green technologies and improve the production environment. The existence of poor information reduces the effectiveness of regulatory authorities, but incentive policies can reduce the opportunistic behavior of enterprises and obtain better environmental regulation benefits (La Nauze and Mezzetti, 2019). This leads to the following three hypotheses:

H2a: Incentive-based environmental regulation can enhance manufacturing enterprises' green product innovation capability.

H2b: Incentive-based environmental regulation can enhance manufacturing enterprises' green process innovation capability.

H2c: Incentive-based environmental regulation can enhance manufacturing enterprises' terminal technology governance capability.

2.4 The Effect of Voluntary Environmental Regulations

Voluntary environmental regulation, which is an innovation of traditional environmental regulation, arises from voluntary agreements. Voluntary environmental regulation is based on the voluntary participation of enterprises, as the government does not impose a mandatory regulation. It is usually advocated by industry associations, enterprises, and third-party certification bodies; and includes agreements, commitments, plans, and other content. However, enterprises can decide whether they want to be regulated (Qin and Sun, 2020). The responsibility of voluntary environmental regulation lies with the enterprise, although

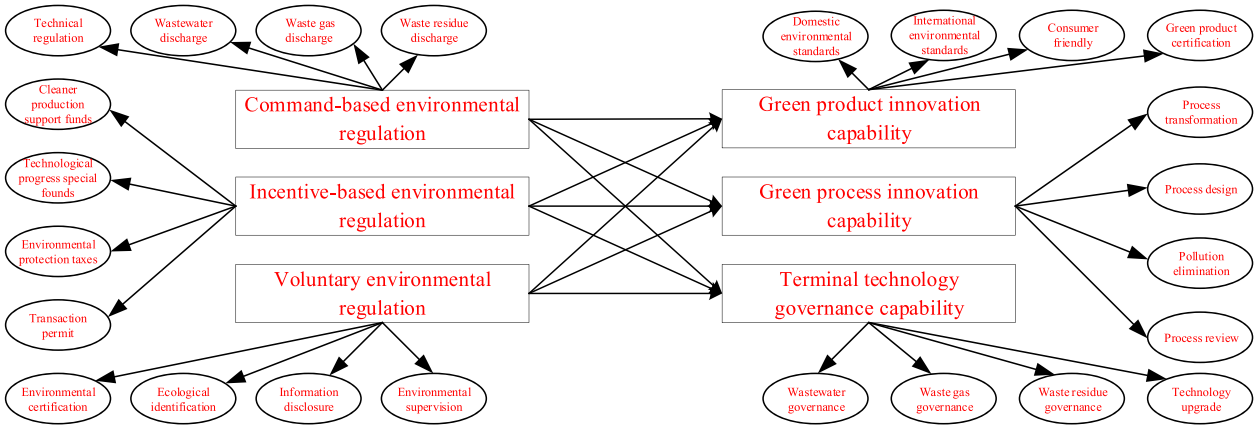

FIGURE 1 | Conceptual framework.

the enterprise can usually make an independent choice. This differs from the government's mandatory emission reduction regulations and external environmental protection incentives. Participation in voluntary environmental regulation not only helps obtain government funding, technology, and policy support but also improves enterprises' market reputation (Ju et al., 2020). Enterprises can begin based on their circumstances, do what they can, and stimulate their enthusiasm for green technological innovation internally. Green technological innovation is the foundation for the effective implementation of voluntary environmental regulation, and enterprises drive green technological innovation to sustain voluntary environmental regulation. Voluntary environmental regulation stems from enterprises' own social responsibility. Under the premise of no subsidy, enterprises can actively invest resources to implement environmental protection measures and reduce their harm to the environment. In order to achieve ecological friendliness, enterprises will spontaneously improve the green technology innovation capability, improve the production process, strengthen the terminal governance capability, and promote the development of green products. In the face of a positive environmental protection attitude, the internal staff of the enterprise will innovate their environmental concept, implement the green development strategy, and promote the improvement of the enterprise's green technology innovation capability. To analyze this phenomenon, we propose the following research hypotheses:

H3a: Voluntary environmental regulation can enhance manufacturing enterprises' green product innovation capability.

H3b: Voluntary environmental regulation can enhance manufacturing enterprises' green process innovation capability.

H3c: Voluntary environmental regulation can enhance manufacturing enterprises' terminal technology governance capability.

2.5 Conceptual Framework

Figure 1 illustrates the conceptual framework of this study. Based on the above discussion and the idea of structural equation modelling (SEM), the conceptual framework contains three exogenous variables, three endogenous variables, and nine causal paths.

3 RESEARCH MODEL

3.1 Factor Decomposition and Questionnaire Design

After appropriate semantic transformation based on factor decomposition, we designed a questionnaire survey form for data collection.

3.1.1 Element Decomposition of Government Environmental Regulations

The element decomposition of command-based, incentive-based, and voluntary environmental regulations can be effectively implemented based on existing research and knowledge of China's environmental regulations (Shi, 2019).

The command-based environmental regulation elements are divided into the following indicators: first is technical regulation, formulation of scientific clean technology standards for enterprises; second is wastewater discharge, preparation of clear requirements for wastewater discharge; third is waste gas discharge, creation of clear requirements for waste gas discharge; and fourth is waste residue discharge, devising clear standards for waste residue discharge.

The incentive-based environmental regulation elements are divided into the following indicators: first is cleaner production support funds, the appropriate allocation of cleaner production support funds for enterprises; second is technological progress special founds, the appropriate allocation of technical progress special funds for enterprises; third is environmental protection taxes, the reasonable and standardized collection of environmental protection taxes; and fourth is transaction permit, the appropriate transaction permit support for enterprises.

The voluntary environmental regulation elements are divided into the following indicators: first is environmental certification, that enterprises actively obtain the environmental certification

TABLE 1 | Sample characteristics.

Attributes	Category	Sample Size	Share %	Attributes	Category	Sample Size	Portion %
Sample geographical distribution	East China	68	17	Distribution of sample employees (person)	≤100	52	13
	Southwest China	56	14		101 ~ 200	68	17
	the Northwestern District	56	14		201 ~ 300	88	22
	North China	68	17		301 ~ 400	72	18
	Central and Southern China region	56	14		401 ~ 500	68	17
	Southeast China	64	16		≥500	52	13
	Northeastern China	32	8	Sample fixed asset distribution (Yuan)	<10 M	36	9
Sample industry distribution	Food	32	8		10 ~ 20 M	40	10
	Textile	28	7		20 ~ 30 M	48	12
	Clothing	20	5		30 ~ 40 M	56	14
	Leather	28	7		40 ~ 50 M	52	13
	Furniture	24	6		50 ~ 60 M	40	10
	Petrochemical	28	7		60 ~ 70 M	36	9
	Chemical	24	6		70 ~ 80 M	32	8
	Medicine	32	8		80 ~ 90 M	24	6
	Rubber	12	3		90 ~ 100 M	20	5
	Plastic	12	3		≥100 M	16	4
	Machine Tool	16	4	Sample profit distribution (Yuan)	≤1 M	76	19
	Equipment	40	10		1.01 ~ 2 M	96	24
	Electronic Communications	32	8		2.01 ~ 3 M	88	22
	Instrument	28	7		3.01 ~ 5 M	68	17
	Black Metal	20	5		4.01 ~ 5 M	40	10
	Other	24	6		≥5 M	32	8

TABLE 2 | Cronbach's α and CR values of each factor.

Factor	Cronbach's α	CR
Command-based Environmental Regulation	0.786	0.845
Incentive-based Environmental Regulation	0.812	0.856
Voluntary Environmental Regulation	0.801	0.764
Green Product Innovation Capability	0.734	0.802
Green Process Innovation Capability	0.694	0.746
Terminal Technology Governance Capability	0.675	0.813

issued by the industry association; second is ecological identification, that enterprises actively acquire the ecological identification issued by the industry association; third is information disclosure, that enterprises implement environmental information disclosure to society; and fourth is environmental supervision, that enterprises actively require the supervision of the environmental protection department.

3.1.2 Element Decomposition of Green Innovation Capability

The element decomposition of green product innovation, green process innovation, and terminal governance technology capabilities can be effectively implemented based on existing research and insights into the green technology innovation capabilities of Chinese enterprises (Wang et al., 2019).

The elements of green product innovation capabilities are divided into the following indicators: first is domestic environmental standards, that the products meet the domestic environmental protection standards; second is international environmental standards, that the products meet the international environmental protection standards; third is consumer friendly, that the products benefit the consumers' physical and mental health; and fourth is green product certification, that the products can easily pass green product certification.

TABLE 3 | Factor analysis results.

Factor	Standard load	AVE	KMO	Bartlett sphericity
Command-based Environmental Regulation	0.842	0.601	0.832	0.000
Incentive-based Environmental Regulation	0.768	0.562		
Voluntary Environmental Regulation	0.831	0.591		
Green Product Innovation Capability	0.853	0.614		
Green Process Innovation Capability	0.776	0.584		
Terminal Technology Governance Capability	0.793	0.605		

TABLE 4 | Results of the model path coefficient test.

	Coefficient	95%CI	
		Lower	Upper
Command-based Environmental Regulation → Green Product Innovation Capability	0.31	0.23	0.35
Command-based Environmental Regulation → Green Process Innovation Capability	0.25	0.19	0.31
Command-based Environmental Regulation → Terminal Technology Governance Capability	0.32	0.27	0.42
Incentive-based Environmental Regulation → Green Product Innovation Capability	0.34	0.31	0.45
Incentive-based Environmental Regulation → Green Process Innovation Capability	0.42	0.36	0.51
Incentive-based Environmental Regulations → Terminal Technology Governance Capability	0.13	0.15	0.23
Voluntary Environmental Regulation → Green Product Innovation Capability	0.27	0.19	0.31
Voluntary Environmental Regulation → Green Process Innovation Capability	0.18	0.09	0.17
Voluntary environmental regulation → Terminal Technology Governance Capability	0.15	0.21	0.32

Note: CI, confidence interval.

TABLE 5 | Test results.

Hypothesis	Path	Path coefficient	T Value	Test result
H1a	Command-based Environmental Regulation → Green Product Innovation Capability	0.33	3.89	supported
H1b	Command-based Environmental Regulation → Green Process Innovation Capability	0.30	4.09	supported
H1c	Command-based Environmental Regulation → Terminal Technology Governance Capability	0.41	5.76	supported
H2a	Incentive-based Environmental Regulation → Green Product Innovation Capability	0.29	3.10	supported
H2b	Incentive-based Environmental Regulation → Green Process Innovation Capability	0.40	5.78	supported
H2c	Incentive-based Environmental Regulations → Terminal Technology Governance Capability	0.08	1.07	not supported
H3a	Voluntary Environmental Regulation → Green Product Innovation Capability	0.36	6.66	supported
H3b	Voluntary Environmental Regulation → Green Process Innovation Capability	0.23	1.87	not supported
H3c	Voluntary environmental regulation → Terminal Technology Governance Capability	0.10	1.29	not supported

TABLE 6 | List of goodness-of-fit indices.

Goodness-of-fit index name	Goodness-of-fit index value	Conformity
χ^2/df	1.336	High
GFI	0.902	Low
AGFI	0.928	Moderate
RMSEA	0.022	High
NFI	0.936	Moderate
TLI	0.889	Close to match
CFI	0.950	High
AIC	78.156	Moderate
CAIC	120.337	Low
ECVI	0.401	Moderate

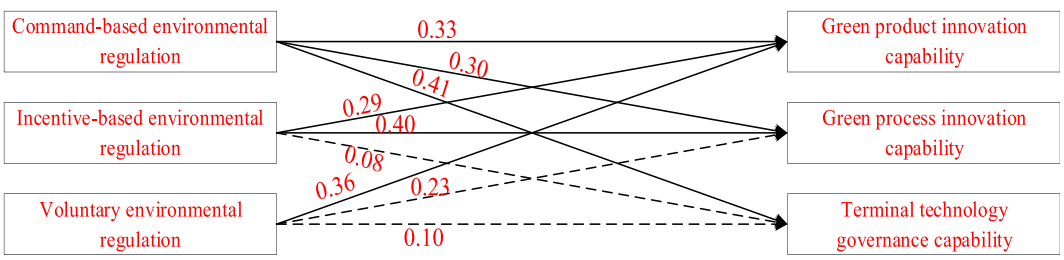

FIGURE 2 | Model test results.

The elements of green process innovation capabilities are divided into the following indicators: first is process transformation, strengthening the green transformation of the traditional process; second is process design, enhancing environmental protection in the new process design; third is pollution elimination, eliminating heavy pollution in the old process; and fourth is process review, strengthening self-testing and supervision of the green process.

The elements of terminal technology governance capabilities are divided into the following indicators: first is wastewater governance, the safe treatment of wastewater discharged by enterprises in a timely and effective manner; second is waste gas governance, the safe treatment of waste gas discharged by enterprises in a timely and effective manner; third is waste residue governance, the safe treatment of waste residue discharged by enterprises in a timely and effective manner; and fourth is technology upgrade, the continuous upgradation of "three waste" treatment technologies of enterprises.

3.2 Data Collection and Analysis

The study sample comprised manufacturing enterprises in China, with data collection using a seven-point scale. The perceived degree of efficiency and quality of command-based, incentive-based, and voluntary environmental regulations is examined from the enterprises' perspective. In addition, the implementation degree of green product innovation capabilities, green process innovation capabilities, and terminal technology governance capabilities is scrutinized from the enterprises' perspective. The data survey began on 1 February 2020 and ended on 12 March 2020. The survey covered various regions in China to demonstrate the popularity of policies. Among them, the East China, North China and Southeast China account for a large share of research samples due to their developed manufacturing industries. The survey sample covered a wide range of manufacturing sectors, but the equipment accounted for the largest share, followed by food, medicine, and electronic communications. This data distribution reflects the universality of the research survey and strongly illustrates the real situation of environmental regulation in China. The data survey of this study was conducted in two stages. The first stage is mainly about environmental regulation, and the second stage is green innovation ability of enterprises. The respondents were all manufacturing companies. The two-stage survey was conducted simultaneously. In total, 608 questionnaires were distributed and 485 were recovered with a recovery rate of 79.8%. From the recovered questionnaires, 63 low-quality questionnaires such as missing filling, wrong filling and single data were removed, and there were 422 remaining questionnaires. At the same time, in order to ensure the equilibrium of sample size, regions with too dense sample number were removed, and a total of 400 valid questionnaires were finally retained as the sample population for data analysis. **Table 1** provides the sample characteristics of the study.

3.3 Model Testing and Results

Analysis of the reliability and validity of the questionnaire data is needed before performing the data analysis. The reliability of the variable is mainly tested by Cronbach's α and the combined reliability (CR). The comprehensive α value of the questionnaire was 0.823, the green process innovation capability α value was 0.694, the terminal technical governance capability α value was 0.675, and the α values of the remaining four variables were greater than 0.7. On this basis, the CR values of each variable exceeded 0.7. It can be concluded that the data obtained in this survey have high reliability. **Table 2** shows the test results.

Lisrel8.7 and SPSS18.0 software were used for factor analysis of questionnaire data. According to the exploratory factor analysis results, the KMO value was 0.832, exceeding the 0.8, indicates that the correlation between variables is strong (Tabachnick and Fidell, 2007; Hair et al., 2010). The *p*-value of Bartlett sphericity test was 0.000, less than 0.01, shows good structural validity of the scale, which was suitable for factor analysis. The load coefficients of six factors were obtained by factor analysis, and then the corresponding AVE value was calculated. It was found that the AVE value of each variable exceeded 0.5, indicating that the scale had good discriminant validity. The results are shown in the following **Table 3**.

After the reliability and validity test of the questionnaire data, it was found that the obtained data performed well and could be used for follow-up tests. **Table 4** shows that the assumed structural equation models are not all significant (coefficient not in confidence intervals). Incentive-based environmental regulation had not significant direct impact on terminal technology governance capability ($\beta = 0.13$, CI = [0.15,0.23]). Meanwhile, voluntary environmental regulation had not significant direct impact on green process innovation capability ($\beta = 0.18$, CI = [0.09,0.17]) and terminal technology governance capability ($\beta = 0.15$, CI = [0.21,0.32]). Based on this, the model was tested using SPSS18.0 and Lisrel8.7. **Table 5** and **Figure 2** show the test results.

The test results show the following: 1) the path coefficients of H1a, H1b, H1c, H2a, H2b, and H3a are high and significant; thus, they pass the test. 2) The H3b path coefficient is high but lacks significance; therefore, it fails the test. 3) The path coefficients of H2c and H3c are low and lack significance; therefore, they fail the test.

Table 6 shows the list of goodness-of-fit indices. Through a comprehensive assessment of the goodness-of-fit index's degree of conformity, the model is shown to have a good fit, and the study conclusions are true and reliable.

4 CONCLUSIONS AND POLICY IMPLICATIONS

4.1 Conclusion

The test results show that the Porter hypothesis is supported for China's manufacturing enterprises but cannot be completely confirmed. China's environmental regulations drive green technological innovations of manufacturing enterprises and have partially promoted the growth of green technological innovation capabilities. However, the promotion function still has many limitations that need to be addressed. Command-based environmental regulation has the strongest promotion effect

(Guo and Yuan, 2020), followed by incentive-based environmental regulation. Voluntary environmental regulation has the weakest effect.

Specifically, the results show that command-based environmental regulation supports the green product innovation capability, green process innovation capability, and terminal governance technology capability of manufacturing enterprises. Conversely, incentive-based environmental regulation has a promotion effect on manufacturing enterprises' green product innovation capability and green process innovation capability but not on terminal technology governance capability. Finally, voluntary environmental regulation can only promote the green product innovation capability of manufacturing enterprises and not the green process innovation and terminal technology governance capabilities. Under green technology innovation capability cultivation of manufacturing enterprises, green product innovation capability has been most effectively promoted, followed by green process innovation capability. Terminal governance technology capability has been promoted the least.

The test results show that environmental regulation has the potential to promote the development of green technology innovation, and then realize the ecological protection. In today's world, environmental protection has become the theme of development, and all countries are exploring the path of sustainable development. Based on the practice of China's manufacturing industry, this paper verifies the promotion function of environmental regulation on green technology innovation, indicating that developing countries can effectively realize the transformation of their manufacturing enterprises and reduce their environmental pollution with the help of government environmental regulation. Around the world, most developing countries with backward economic and technological technology are in urgent need of new roads to achieve sustainable environmental development and alleviate the global environmental crisis. China's experience is worth learning from.

4.2 Policy Implications

The results show that various environmental regulations have different effects on enterprises' green technology innovation. However, the role of government environmental regulations in enterprises' technological innovation has not been clarified. Therefore, environmental regulation must involve measures based on Chinese characteristics to ensure sustainable economic development and realize the coordinated symbiosis of the ecological economy (Du et al., 2021). Based on the model results and understanding of environmental regulation implementation in Chinese manufacturing enterprises, we propose the following specific strategies and paths to optimize environmental regulation.

First, China's pollution trading permit system should be consolidated. Incentive-based environmental regulation has hitherto been unable to completely support green technological innovation capability in China because of the ineffective implementation of the pollution trading permit system and the prevalence of "one-license" management. The current pollution discharge permit system does not meet the standards of environmental protection departments, as the permit is only a symbolic certificate with ambiguous functions. The enhancement of China's emission trading permit system requires not only the adoption of the Western system for issuing emission trading permits but also the promotion of legislation for China's emission trading permit system through the promulgation of specific laws and regulations at the national level.

Second, the implementation of voluntary environmental regulation should be improved. The results show that the implementation of voluntary environmental regulation is weaker compared to command-based and incentive-based environmental regulations, indicating that it has room for improvement. Voluntary environmental regulation needs to achieve the active participation of enterprises on the basis of meeting the government's environmental supervision goals. When the government forcibly implements environmental regulation, enterprises have to allocate innovation funds to meet the needs of environmental regulation, but when the government's coercive force is insufficient, the speculation of enterprises will hinder the implementation of green innovation agreements. Therefore, the improvement of voluntary environmental regulation in China needs the participation of the government. Through exploring appropriate regulatory intensity, enterprises can control their opportunistic behaviors and achieve the goal of environmental governance.

Third, the terminal technology governance capability of manufacturing enterprises should be significantly improved through environmental regulations. Incentive-based and voluntary environmental regulations do not promote terminal technology governance capability. Incentive-based environmental regulation can potentially improve overall efficiency and policy flexibility, whereas voluntary environmental regulation can better motivate enterprises. Therefore, the improvement of environmental regulations needs to cultivate terminal technology governance capability and further improve incentive-based and voluntary environmental regulations. The government's current restrictions on the "three wastes" emissions of manufacturing enterprises rely on compulsory systems rather than enterprises' own initiative.

Fourth, the internal structure of environmental regulations should be optimised and simultaneously implemented. China's environmental regulations show obvious characteristics of abnormality, in which command-based environmental regulation stands out and promotes green technological innovation. In contrast, voluntary environmental regulation is struggling to accommodate green economic development. Thus, developing the internal structure of environmental regulations and improving the organic integration of the internal elements of various environmental regulations is crucial for the development of China's environmental regulations. Monitoring by stakeholders can ensure the adoption of voluntary environmental regulations and generate benefits beyond mandatory regulations, whereas incentive-based environmental

regulation can bridge the benefit loss caused by mandatory regulations.

Fifth, deepen the exploration of environmental regulation theory and promote the linkage of international environmental governance. Environmental regulation is in the exploratory stage in China has not formed a perfect theoretical system. Current regulations cannot fully mobilize the enterprises' green technology innovation capability. Therefore, it is necessary to promote the corresponding environmental regulation strategies according to the characteristics of different industries according to local conditions, and take into account the environmental regulation and the interests of enterprises to effectively achieve the goal of environmental governance. The international community pays more attention to environmental governance has formed an effective governance model after years of development. China can use its advanced experience to further improve its environmental regulation system. China's governance model has high reference value for developing countries. Through the government to control environmental pollution, it has opened up a new road of governance for the developing countries with insufficient technology funds.

Sixth, strengthen the effectiveness of environmental regulation in the face of uncertain environment. The global economy is suffering from the impact of COVID-19. Economic development is full of uncertainties, and it will be difficult to ensure the normal implementation of government policies, thus exacerbating the impact of uncertainties (Işık et al., 2019b). When enterprises lose faith in government, it prevents governments from easing policy uncertainty (Ahmad et al., 2021). Environmental regulations need make use of the government's credibility to ensure their implementation rate and avoid damage to the early results due to the COVID-19. At the same time, enterprises should take this opportunity to adjust their own technical structure, cultivate green competitiveness, and jointly achieve the goal of environmental protection.

5 LIMITATIONS AND FUTURE PROSPECTS

This paper explores the correlation between environmental regulation and green technology innovation through quantitative analysis, finds the deficiencies of current environmental regulation in China based on the reality, and makes an in-depth study of three kinds of environmental regulations. However, limited by my ability, this study has the following limitations: 1) Lack of targeted analysis and processing through the collected data, which do not highlight the environmental regulation characteristics of different regions, so in-depth analysis is needed. 2) Lack of thinking on the market. The trading system represented by emission permits has emerged in western countries. The power of market can help enterprises to allocate ecological resources efficiently, which is more conducive to the realization of technological innovation. 3) Lack of analysis on the negative effects of environmental regulations. Mandatory policies and regulations will inevitably lead to resistance from enterprises and reduce market vitality.

Future research will focus on two parts: First, strengthen the analysis of the "double-edged sword" effect of environmental regulation. According to the research conclusion, environmental regulation effectively promotes the improvement of the enterprise green innovation capability, but the regulations based on the government force damage the healthy development of the market. Therefore, future research will focus on the dual effects of government involvement. Secondly, this paper studies the direct impact of environmental regulations on the green innovation ability of enterprises, but in the actual operation process, there are differences in the implementation effect of environmental regulations caused by different variables. Therefore, further research needs to consider the effect of the intermediary effect.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethics review and approval/written informed consent was not required as per local legislation and institutional requirements.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

REFERENCES

Ahmad, M., Akhtar, N., Jabeen, G., Irfan, M., Khalid Anser, M., Wu, H., et al. (2021). Intention-Based Critical Factors Affecting Willingness to Adopt Novel Coronavirus Prevention in Pakistan: Implications for Future Pandemics. *Int. J. Environ. Res. Public Health* 18 (11), 6167. doi:10.3390/ijerph18116167

Cai, X., Zhu, B., Zhang, H., Li, L., and Xie, M. (2020). Can Direct Environmental Regulation Promote Green Technology Innovation in Heavily Polluting Industries? Evidence from Chinese Listed Companies. *Sci. Total Environ.* 746, 140810. doi:10.1016/j.scitotenv.2020.140810

Chen, X., Zhang, T. J., Wei, Z. X., and Zhu, J. J. (2018). Research on the Strategic Design and Implementation of Ecological Emergency Decision Support System. *J. Hunan. Coll. Fin. Econ.* 34 (175), 113–119. doi:10.16546/j.cnki.cn43-1510/f.2018.05.014

Chen, Y., Yao, Z., and Zhong, K. (2022). Do environmental Regulations of Carbon Emission and Air Pollution Foster Green Technology Innovation: Evidence from China's Prefecture-Level Cities. *J. Clean. Prod.* 350, 131537. doi:10.1016/j.jclepro.2022.131537

De Santis, R., Esposito, P., and Lasinio, C. J. (2021). Environmental Regulation and Productivity Growth: Main Policy Challenges. *Int. Econ.* 165, 264–277. doi:10.1016/j.inteco.2021.01.002

Deng, F., and Chen, C. H. (2020). R&D Input Intensity and Green Innovation Efficiency in China - a Threshold Study Based on Environmental Regulation. *Indust. Technol. Econ.* 2, 30–36. doi:10.3969/j.issn.1004-910X.2020.02.004

Dong, Z., He, Y., Wang, H., and Wang, L. (2020). Is There a Ripple Effect in Environmental Regulation in China?–Evidence from the Local-Neighborhood Green Technology Innovation Perspective. *Ecol. Indic.* 118, 106773. doi:10.1016/j.ecolind.2020.106773

Du, K., Cheng, Y., and Yao, X. (2021). Environmental Regulation, Green Technology Innovation, and Industrial Structure Upgrading: The Road to the Green Transformation of Chinese Cities. *Energy Econ.* 98, 105247. doi:10.1016/j.eneco.2021.105247

Fethi, S., and Rahuma, A. (2020). The Impact of Eco-Innovation on CO2 Emission Reductions: Evidence from Selected Petroleum Companies. *Struct. Change Econ. Dyn.* 53, 108–115. doi:10.1016/j.strueco.2020.01.008

Guo, R., and Yuan, Y. (2020). Different Types of Environmental Regulations and Heterogeneous Influence on Energy Efficiency in the Industrial Sector: Evidence from Chinese Provincial Data. *Energy. Policy.* 145, 111747. doi:10.1016/j.enpol.2020.111747

Hair, J., Black, W., Babin, B., Anderson, R., and Tatham, R. (2010). *Multivariate Data Analysis*, 2. New Jersey: Pearson Prentice Hall. Alih bahasa: Soleh Rusyadi Maryam.

He, W., Chen, X., and Liu, Z. J. (2022). Can Anti-Corruption Help Realize the "Strong" Porter Hypothesis in China? Evidence from Chinese Manufacturing Enterprises. *J. Asian Econ.* 80, 101473. doi:10.1016/j.asieco.2022.101473

Herman, K. S., and Xiang, J. (2019). Induced Innovation in Clean Energy Technologies from Foreign Environmental Policy Stringency? *Technol. Forecast. Soc. Change* 147, 198–207. doi:10.1016/j.techfore.2019.07.006

Hicks, J. (1963). *The Theory of Wages*. London: Springer.

Işık, C. (2013). The Importance of Creating a Competitive Advantage and Investing in Information Technology for Modern Economies: an ARDL Test Approach from Turkey. *J. Knowl. Econ.* 4 (4), 387–405. doi:10.1007/s13132-011-0075-2

Işık, C., Ongan, S., and Özdemir, D. (2019a). Testing the EKC Hypothesis for Ten US States: an Application of Heterogeneous Panel Estimation Method. *Environ. Sci. Pollut. Res.* 26 (11), 10846–10853. doi:10.1007/s11356-019-04514-6

Işık, C., Sirakaya-Turk, E., and Ongan, S. (2019b). Testing the Efficacy of the Economic Policy Uncertainty Index on Tourism Demand in USMCA: Theory and Evidence. *Tour. Econ.* 26 (8), 1344–1357. doi:10.1177/1354816619888346

Jiang, Z., and Lyu, P. (2021). Stimulate or Inhibit? Multiple Environmental Regulations and Pollution-Intensive Industries' Transfer in China. *J. Clean. Prod.* 328, 129528. doi:10.1016/j.jclepro.2021.129528

Jiang, Z., Wang, Z., and Lan, X. (2021). How Environmental Regulations Affect Corporate Innovation? the Coupling Mechanism of Mandatory Rules and Voluntary Management. *Technol. Soc.* 65, 101575. doi:10.1016/j.techsoc.2021.101575

Ju, K., Zhou, D., Wang, Q., Zhou, D., and Wei, X. (2020). What Comes after Picking Pollution Intensive Low-Hanging Fruits? Transfer Direction of Environmental Regulation in China. *J. Clean. Prod.* 258, 120405. doi:10.1016/j.jclepro.2020.120405

La Nauze, A., and Mezzetti, C. (2019). Dynamic Incentive Regulation of Diffuse Pollution. *J. Environ. Econ. Manag.* 93, 101–124. doi:10.1016/j.jeem.2018.11.009

Li, M., and Gao, X. (2022). Implementation of Enterprises' Green Technology Innovation under Market-Based Environmental Regulation: An Evolutionary Game Approach. *J. Environ. Manag.* 308, 114570. doi:10.1016/j.jenvman.2022.114570

Li, G. P., Li, Y. G., and Quan, J. M. (2018). Environmental Regulation, R&D Investment and Firms' Green Technology Innovation Capability. *Sci. Sci. Technol. Manage.* 39 (11), 61–73. CNKI:SUN:KXXG.0.2018-11-005.

Li, L. (2017). The Degree of Environmental Regulation and Firms' Green Technology Innovation Performance. *Econ. For.* 4, 97–102. doi:10.3969/j.issn.1003-3580.2017.04.024

Li, N. B. (2019). Environmental Regulation and Corporate Green Technology Innovation - a Conditional Process Analysis. *Inn. Mong. Soc. Sci. Chin. Ed.* 40 (6), 109–115. doi:10.14137/j.cnki.issn1003-5281.2019.06.016

Lin, Y. X., Sha, K. C., and Wang, J. (2020). Practical Experience and Inspiration of Foreign Emission Permit System. *Environ. Impact. Assess.* 42 (1), 14–16. CNKI:SUN:SXHS.0.2020-01-004.

Liu, X. Y., and Zhao, Y. M. (2012). Exploration of Green Technology Innovation of Enterprises in the Context of Environmental Regulation. *Technol. Econ. Manage. Res.* 2, 43–46. doi:10.3969/j.issn.1004-292X.2012.02.010

Liu, L., Jiang, J., Bian, J., Liu, Y., Lin, G., and Yin, Y. (2021). Are Environmental Regulations Holding Back Industrial Growth? Evidence from China. *J. Clean. Prod.* 306, 127007. doi:10.1016/j.jclepro.2021.127007

Lu, J., Imran, M., Haseeb, A., Saud, S., Wu, M., Siddiqui, F., et al. (2021). Nexus between Financial Development, FDI, Globalization, Energy Consumption and Environment: Evidence from BRI Countries. *Front. Energy Res.* 9, 707590. doi:10.3389/fenrg.2021.707590

Lv, C., Shao, C., and Lee, C.-C. (2021). Green Technology Innovation and Financial Development: Do Environmental Regulation and Innovation Output Matter? *Energy Econ.* 98, 105237. doi:10.1016/j.eneco.2021.105237

Mensah, C. N., Long, X., Dauda, L., Boamah, K. B., Salman, M., Appiah-Twum, F., et al. (2019). Technological Innovation and Green Growth in the Organization for Economic Cooperation and Development Economies. *J. Clean. Prod.* 240, 118204.1–118204.10. doi:10.1016/j.jclepro.2019.118204-

Nie, X., Wu, J., Zhang, W., Zhang, J., Wang, W., Wang, Y., et al. (2021a). Can Environmental Regulation Promote Urban Innovation in the Underdeveloped Coastal Regions of Western China? *Mar. Policy* 133, 104709. doi:10.1016/j.marpol.2021.104709

Nie, X., Wu, J., Chen, Z., Zhang, A., and Wang, H. (2021b). Can Environmental Regulation Stimulate the Regional Porter Effect? Double Test from Quasi-Experiment and Dynamic Panel Data Models. *J. Clean. Prod.* 314, 128027. doi:10.1016/j.jclepro.2021.128027

Nie, X., Wu, J., Wang, H., Li, L., Huang, C., Li, W., et al. (2022). Booster or Stumbling Block? the Role of Environmental Regulation in the Coupling Path of Regional Innovation under the Porter Hypothesis. *Sustainability* 14 (5), 2876. doi:10.3390/su14052876

Niebel, C. (2021). The Impact of the General Data Protection Regulation on Innovation and the Global Political Economy. *Comput. Law Secur. Rev.* 40, 105523. doi:10.1016/j.clsr.2020.105523

Ouyang, X., Li, Q., and Du, K. (2020). How Does Environmental Regulation Promote Technological Innovations in the Industrial Sector? Evidence from Chinese Provincial Panel Data. *Energy. Policy.* 139, 111310. doi:10.1016/j.enpol.2020.111310

Porter, M. E., and Linde, C. v. d. (1995). Toward a New Conception of the Environment-Competitiveness Relationship. *J. Econ. Perspect.* 9 (4), 97–118. doi:10.1257/jep.9.4.97

Qin, Y., and Sun, H. (2020). The Relationship between Voluntary Participatory Environmental Regulation and Corporate R&D Innovation. *Sci. Technol. Manage. Res.* 4, 254–262. CNKI:SUN:KJGL.0.2020-04-033.

Ramanathan, R., He, Q., Black, A., Ghobadian, A., and Gallear, D. (2017). Environmental Regulations, Innovation and Firm Performance: A Revisit of the Porter Hypothesis. *J. Clean. Prod.* 155, 79–92. doi:10.1016/j.jclepro.2016.08.116

Ren, K., Kong, Y.-S., Imran, M., and Bangash, A. K. (2022). The Impact of the Voluntary Environmental Agreements on Green Technology Innovation: Evidence from the Prefectural-Level Data in China. *Front. Environ. Sci.* 10, 833724. doi:10.3389/fenvs.2022.833724

Saud, S., Chen, S., Haseeb, A., Khan, K., and Imran, M. (2019). The Nexus between Financial Development, Income Level, and Environment in Central and Eastern European Countries: a Perspective on Belt and Road Initiative. *Environ. Sci. Pollut. Res.* 26, 16053–16075. doi:10.1007/s11356-019-05004-5

Shi, C. K. (2019). Exploring the Evolutionary Trajectory of Corporate Green Technology Innovation under Environmental Regulatory Constraints. *J. Econ. Res.* 13, 15–16. doi:10.3969/j.issn.1673-291X.2019.13.007

Song, M., Wang, S., and Zhang, H. (2020). Could Environmental Regulation and R&D Tax Incentives Affect Green Product Innovation? *J. Clean. Prod.* 258, 120849. doi:10.1016/j.jclepro.2020.120849

Song, M., Peng, L., Shang, Y., and Zhao, X. (2022). Green Technology Progress and Total Factor Productivity of Resource-Based Enterprises: A Perspective of Technical Compensation of Environmental Regulation. *Technol. Forecast. Soc. Change* 174, 121276. doi:10.1016/j.techfore.2021.121276

Tabachnick, B. G., and Fidell, L. S. (2007). *Using Multivariate Statistics*. Boston, MA: Pearson Education.

Wang, X. Y., and Liu, Q. (2019). Analysis of the Impact Effect of Environmental Regulation on Firms' Green Technology Innovation. *J. Econ. Res.* 5, 8–11. doi:10.3969/j.issn.1673-291X.2019.05.004

Wang, H., and Zhang, R. (2022). Effects of Environmental Regulation on CO2 Emissions: An Empirical Analysis of 282 Cities in China. *Sustain. Prod. Consum.* 29, 259–272. doi:10.1016/j.spc.2021.10.016

Wang, F. Z., Jiang, T., and Guo, X. C. (2018). Government Quality, Environmental Regulation and Corporate Green Technology Innovation. *Sci. Res. Manage.* 39 (1), 26–33. CNKI:SUN:KYGL.0.2018-01-004.

Wang, Q., Qu, J., Wang, B., Wang, P., and Yang, T. (2019). Green Technology Innovation Development in China in 1990-2015. *Sci. Total Environ.* 696, 134008. doi:10.1016/j.scitotenv.2019.134008

Wei, L., and Zhang, H. (2020). How Environmental Regulations Affect the Efficiency of Green Technology Innovation? *Ajibm* 10 (3), 507–521. doi:10.4236/ajibm.2020.103034

Zhang, Q., and Wu, L. Q. (2017). Dynamic Evolution of Green Technology Innovation in Coal Enterprises under Environmental Regulation. *Coal. Econ. Res.* 37 (11), 51–56. CNKI:SUN:MTJN.0.2017-11-012.

Zhang, Y., Sun, J., Yang, Z., and Wang, Y. (2020). Critical Success Factors of Green Innovation: Technology, Organization and Environment Readiness. *J. Clean. Prod.* 264, 121701. doi:10.1016/j.jclepro.2020.121701

Zhang, H., Liu, Z., and Zhang, Y.-J. (2022). Assessing the Economic and Environmental Effects of Environmental Regulation in China: The Dynamic and Spatial Perspectives. *J. Clean. Prod.* 334, 130256. doi:10.1016/j.jclepro.2021.130256

Zhang, D. (2022). Environmental Regulation and Firm Product Quality Improvement: How Does the Green Washing Response? *Int. Rev. Financ. Anal.* 80, 102058. doi:10.1016/j.irfa.2022.102058

Zhao, X., Mahendru, M., Ma, X., Rao, A., and Shang, Y. (2022). Impacts of Environmental Regulations on Green Economic Growth in China: New Guidelines Regarding Renewable Energy and Energy Efficiency. *Renew. Energy* 187, 728–742. doi:10.1016/j.renene.2022.01.076

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.