sustainability

MDPI

Article

Influence of Environmental Regulation on the International Competitiveness of the High-Tech Industry: Evidence from China

Wenjuan Tu * and Rui Shi

School of Management, Jiangsu University, Zhenjiang 212013, China
* Correspondence: tuwj@ujs.edu.cn

Abstract: Environmental regulation has become a significant way to achieve sustainable development. Taking the panel data of China's high-tech industries from 2007–2016 in 30 provinces and cities as a sample, regression models are established to study the impact of three different types of environmental regulations on international competitiveness and the moderating effect of R&D (research & development) investment. The results show that the impact of environmental regulations on the international competitiveness of high-tech industries is related to the type of environmental regulation. There is a significant negative correlation between economic environmental regulation (EER) and the international competitiveness of high-tech industries, and R&D investment has a significant inhibitory effect on the relationship between the two. For both commanding environmental regulation (CER) and participatory environmental regulation (PER), R&D investment plays a significant moderating role in environmental regulation and the international competitiveness of high-tech industries. The impact of all three environmental regulations on R&D investment was positive but not significant. Finally, based on these research conclusions, a few countermeasures and suggestions are discussed for the formulation of China's environmental regulation policies and the development of high-tech industries.

Keywords: environmental regulation; high-tech industry; international competitiveness; R&D investment; moderating effects; regression model

Citation: Tu, W.; Shi, R. Influence of Environmental Regulation on the International Competitiveness of the High-Tech Industry: Evidence from China. *Sustainability* **2023**, *15*, 677. https://doi.org/10.3390/su15010677

Academic Editors: Feng Wang, Huaping Sun and Keliang Wang

Received: 4 October 2022
Revised: 9 December 2022
Accepted: 26 December 2022
Published: 30 December 2022

1. Introduction

In recent years, China's economy has continued to develop rapidly, but due to the irrational use of resources in traditional economic methods, serious damage to the ecological environment has been caused. In the face of the contradiction between production development and environmental protection, environmental regulation has become the only means of sustainable development. The growing concern about environmental destruction and pollution, coupled with increasing greenhouse gas emissions, has led to the adoption of various policies aimed at achieving a green environment [1]. In 2020, China proposed to reach carbon peaks by 2030 and achieve carbon neutrality by 2060. Enterprises play an important role in reducing carbon emissions. The intensity and severe impact of carbon emissions on the environment have been witnessed globally [2], and the green development of enterprises has become an inevitable trend. The high-tech industry has the characteristics of high added value and high technical content and has become the fastest-growing industry in China. According to the data of the Statistical Communiqué on National Economic and Social Development in 2021, the added value of high-tech manufacturing in the whole year increased by 18.2% over last year, and the investment in high-tech industries increased by 17.1% over the previous year. However, high-tech industries also produce a large amount of pollution in the production process, mainly manifested in the "three wastes" such as wastewater, waste gas, and solid waste [3]. In addition, some polluting processes in the production process of high-tech products are involved in the industrial

chain [4]. High-quality economic development inevitably requires high-tech industries to minimize environmental damage, and following the concept of green development to improve the intensity of environmental regulations gradually is an urgent need for the high-quality development of China's economy [5]. The importance of high-tech industries and the necessity of environmental regulations have made high-tech industries pay more attention to generating profits and improving international competitiveness while controlling pollution generated in the process of production and operation.

Since the concept of environmental regulation was proposed, many studies have followed. One of the earliest and more representative views is the Porter hypothesis [6]: environmental regulation can stimulate technological innovation and promote competitiveness, but this hypothesis has not been unanimously recognized. Despite the skepticism of this optimistic view and the lack of consistent conclusions, the Porter hypothesis has led to a re-examination of the relationship between the environment and the economy [7]. The definition of international competitiveness dates back to the late 1970s when Porter [8] completed his work *The Competition Trilogy*, explained the formation process and evolution of competitiveness, and laid the theoretical foundation for the formation of modern competition theory. In recent years, the Chinese government has attached great importance to environmental protection, and research on environmental regulations in different industries has become a hot topic. On the one hand, high-tech industries are facing external pressures from environmental regulation-related policies and internal pressures of industrial transformation, and on the other hand, they are also facing the direct or indirect, positive or negative impacts that environmental regulations may have on high-tech industries, and environmental regulations occupy an increasingly important position in influencing the competitiveness of high-tech industries. Technological innovation is not only a driving force for economic growth but also an important driving force for solving long-term environmental problems to achieve sustainable development. For the technological innovation and competitiveness of industries, whether the role of environmental regulation is to promote or inhibit has always been a hot issue in the academic community.

Among the existing literature, there is more literature on the relationship between environmental regulation and industrial export competitiveness, whether environmental regulations inhibit export competitiveness [9,10] or whether the strengthening of environmental regulations will promote the competitiveness of industrial exports [11–13]. However, most of the existing literature focuses on the relationship between environmental regulation and the competitiveness of general industries, less research on environmental regulation and the international competitiveness of high-tech industries is carried out, so it can be said that there is still sufficient room for expansion in research on the relationship between environmental regulation and the international competitiveness of high-tech industries. Examining the relationship between environmental regulation and the international competitiveness of high-tech industries can greatly enrich relevant theoretical achievements and provide guidance for the international development of high-tech industries. To ensure the availability of data and the consistency of statistical caliber, this paper takes the relevant data of the high-tech industry in 30 provinces and cities in China (excluding Tibet, Hong Kong, Macao, and Taiwan) from 2007 to 2016 as a sample, to study the impact of different environmental regulations on its international competitiveness, and to introduce enterprises' R&D investment as a moderating variable. The research attempts to answer the following questions. Will China's increased environmental regulations reduce the international competitiveness of high-tech industries? Will the type and severity of environmental regulations affect technological innovation? Does R&D investment have a moderating effect? This issue has not been adequately studied in the available literature. This research will enrich the relevant research on environmental regulation, R&D investment, and international competitiveness of high-tech industries from concepts and theories, supplement the existing research results, and put forward reference suggestions for the development of China's high-tech industries, formulation and implementation of environmental regulation policies, so as to help the development of China's high-tech industries and improve inter-

national competitiveness. This paper also explores the moderating role of R&D investment on the impact of environmental regulation and industrial competitiveness, making the mechanism of environmental regulation clearer. However, due to the availability of data, there are still deficiencies in sample and data selection, which also points the way for future in-depth research.

Lastly, the remaining part of the study is divided as follows. Section 2 is a literature review and theoretical analysis. Section 3 explicates variable descriptions, data selection, and model settings, and Section 4 discusses empirical findings. Finally, Section 5 provides a conclusion and policy implications.

2. Literature Review and Theoretical Analysis

According to the available literature, there are two main views on the relationship between environmental regulation and technological innovation of enterprises: environmental regulation may have a positive or negative impact on the technological innovation of enterprises. Many scholars believe that regulation increases the burden on enterprises and, thus, inhibits technological innovation. Gray et al. [14] conducted an empirical study of 166 companies in the U.S. paper industry and found that strict regulations lead to more investment in energy conservation and emission reduction, resulting in no effective improvement in production technology. Bel et al. [15] argued that for 27 European countries, environmental regulations inhibit technological innovation. Yang et al. [16] found that only one of them has a positive effect on R&D investment in Vietnamese and Malaysian companies by taking two specific environmental regulations in the European Union as examples. Pitelis et al. [17] studied the impact of these three types of tools on innovation activities in the power industry by dividing renewable energy policy into demand-driven, technology-driven, and systemic policy tools and found that systematic tools have a restraining effect, demand-driven tools have a catalytic effect, and technology-driven tools have little impact. There are also empirical analyses that have not found that the government's environmental supervision and inspection activities have a significant impact on technological innovation [18].

In recent years, the studies of China have also gradually been enriched. Tang et al. [19] analyzed the data of 496 A-share industrial enterprises in China from 2002 to 2017 and found that the "Eleventh Five-Year Plan" environmental regulations have a negative impact on the innovation efficiency of enterprises in the short term. Liu et al. [20] found that inappropriate regulations can reduce the marginal efficiency of green technology innovation when analyzing an economic zone in the Yangtze River Basin. Wang et al. [21] conducted a study of six carbon trading pilot areas in China, and the results show that the impact of emissions trading on technological innovation is regionally different and may also produce different results due to different types of regulations or types of technological innovation. Li et al. [22] found that environmental regulations have a non-linear effect on the efficiency of investment in technological innovation but not on their conversion efficiency.

Technological innovation is mainly measured by three types of indicators: R&D investment, patents, and innovation efficiency [23]. Since R&D investment largely determines the innovation ability of industries, based on the existing research literature and research results, Hypothesis 1 is proposed.

Hypothesis 1. *Environmental regulation (ER) is negatively correlated with R&D investment.*

Research on the relationship between environmental regulation and firm competitiveness indicates that environmental regulation may enhance, inhibit, or have a less effective effect on firm competitiveness. Many scholars believe that environmental regulation will have a negative impact on the competitiveness of enterprises [24–28], such as Jeffe [29], who believes that environmental regulation will bring social and ecological benefits, but at the same time, will also increase the cost of enterprises, resulting in disadvantages such as lower productivity and lower competitiveness. Kneller and Manderson [30] argue that

environmental regulations reduce the competitiveness of firms because the total cost of pollution control increases the total costs to the firm, resulting in a decrease in the R&D investment of the company. This, in turn, reduces the competitiveness of the enterprise. Sun et al. [31] examined the interaction between trade and an environmental pollution proxy of carbon dioxide (CO_2) for 49 high-emission countries in Belt and Road regions over the period of 1991–2014 and indicated the existence of an inverted U-form relationship between trade and carbon emissions. For Chinese industrial enterprises, scholars have conducted a series of empirical tests from different perspectives. Hu and Wang [32] used Chinese inter-provincial panel data for spatial metrology analysis and found that environmental regulations not only inhibited local carbon productivity gains but also adversely affected neighboring regions. Tang et al. [33] conducted a study on Chinese industrial enterprises, found that imperative regulations have a restraining effect on enterprise TFPs, and their impact was more significant on high-pollution, small-scale enterprises. Wang et al. [34] found that TFPs in 37 industrial sectors in China are negatively affected by atmospheric environmental regulations.

According to the available literature, there is also abundant evidence that there are three main relationships between environmental regulation and export competitiveness. First, environmental regulations reduce export competitiveness [22,24,26–28]. Second, environmental regulation improves export competitiveness [6,35,36]. Third, the relationship between environmental regulation and export competitiveness is uncertain [37,38]. Li et al. [39] found that there is a significant U-shaped curve relationship between environmental regulation and the export competitiveness of high-tech industries in China from 2001 to 2016.

The command-type environmental regulation (CER) has less flexibility, less incentive effect on the technological innovation of enterprises, and an uncertain effect on industrial competitiveness. Economic environmental regulation (EER) has a large incentive effect on the technological innovation of enterprises and may have a positive effect on industrial competitiveness. Participatory environmental regulation (PER) has strong flexibility, and enterprises take the initiative to assume social responsibilities under pressure, which has limited incentives for technological innovation and may have uncertain effects on industrial competitiveness. Therefore, different types of environmental regulations may produce different environmental regulation performances.

From this, Hypothesis 2 of this paper is proposed:

Hypothesis 2a. *CER and the international competitiveness of the high-tech industry is uncertain.*

Hypothesis 2b. *EER and the international competitiveness of the high-tech industry is positively correlated.*

Hypothesis 2c. *PER and the international competitiveness of the high-tech industry is uncertain.*

For high-tech industries, the more consistent view is that the innovation ability of enterprises has a decisive impact on their competitiveness, especially their international competitiveness. An analysis by foreign scholar Pandit et al. [40] found that there is a positive correlation between the R&D input of enterprises and the output of research and development; R&D investment can increase the company's R&D output. The view that enterprise R&D investment can enhance the international competitiveness of enterprises has been confirmed by most scholars, the high-tech industry has the characteristics of high relevance, which is linked to many enterprises in the process of production and operation, and the application of environmental regulations will naturally have a direct or indirect impact on high-tech enterprises, so the production standards and costs of products will change, and the international competitiveness will naturally change. Businesses may consider growing by scaling up R&D input to improve the technology to produce more environmentally friendly products so as to gain the favor of consumers and meet market demand [41]. In addition, the validity of the Porter hypothesis may be influenced by other

factors [42]. When benchmark regression found that the Porter hypothesis did not hold, He et al. [43] added property protection as a regulatory variable and found that it has a significant regulatory effect and can promote the hypothesis to be true. When other variables are added, such as institutional pressure [44], R&D investment, etc., it strengthens the effect of regulation on the promotion of technological innovation. Javeed et al. [45], taking Pakistan's manufacturing industry as the subject of the study, found that the role of environmental regulations in promoting corporate performance is strengthened after considering the degree of competition in the product market.

Based on the above mechanism analysis, Hypothesis 3 of this paper is proposed:

Hypothesis 3. *The R&D investment has a moderating effect between environmental regulation and the international competitiveness of high-tech industries.*

3. Variable Descriptions, Data Selection, and Model Settings

3.1. Variable Description

3.1.1. Explanatory Variables: Environmental Regulations

The existing measurement methods for environmental regulation can be divided into a single index method and a composite index method. The single index method is usually characterized by pollution control costs, such as the proportion of industrial pollution control investment in total industrial output value [46], or pollution control results, such as pollutant removal rate [47]. In addition, the number of environmental policies [48], the number of environmental agencies and the number of environmental protection workers [49], and the number of environmental-related administrative penalties [50] are often used to reflect the strength of environmental regulations. Alternatively, it can be replaced by indicators that are highly relevant to environmental regulations, such as energy efficiency [51], lead content in gasoline [52], etc. The comprehensive index method comprehensively reflects the policy effects of environmental regulation through composite indicators, such as Saulter [53], to characterize the intensity of regulation from the three dimensions of input, process, and output of environmental regulation. Song and Yang [54] selected the emissions of industrial "three wastes" to construct a comprehensive index of environmental regulation intensity. Luo et al. [55] constructed an index system from the perspective of the main body of environmental regulation and divided environmental regulation into three types: command control, market incentive, and voluntary participation. Yang and Wang [56] divided environmental regulations into command-based environmental regulation (CER), economic environmental regulation (EER), and regulatory environmental regulation (RER).

Each measure has its own advantages and limitations. Considering the heterogeneity of the types of environmental regulation, this paper draws on the research of Wang [37], Luo et al. [55], and Yang and Wang [56] to construct a comprehensive evaluation index system for the intensity of environmental regulation in China. Based on the entropy weight TOPSIS method, the comprehensive level of environmental regulation in 30 provinces and cities in China (excluding Tibet, Hong Kong, Macao, and Taiwan) from 2007 to 2016 was measured, as shown in Table 1.

Table 1. Comprehensive evaluation system for environmental regulation strength.

Level 1 Indicators	Level 2 Indicators
CER	number of construction projects implementing "the environmental impact assessment system"
	number of regulations and administrative rules
	number of environmental administrative penalty cases
EER	the proportion of sewage fee revenue to industrial-added value
	the proportion of investment in industrial pollution control projects to industrial-added value
PER	number of environmental petitions
	number of environmental proposals for NPC and CPPCC sessions

3.1.2. Moderating Variables: R&D Investment

As a knowledge-intensive industry, one of the obvious characteristics of high-tech enterprises is that they have high research and development capabilities, including human, material, and financial investment, of which R&D investment is the most direct and most important indicator reflecting the investment in scientific research and innovation of high-tech enterprises, so this article selects high-tech industries internal expenditure on R&D expenses as a measure of R&D investment; it is the entire amount of expenses actually incurred during the reporting period for the implementation of R&D activities within the investigation unit. Referring to the practice of Shen et al. [23], the R&D intensity of enterprises is used to measure the level of R&D investment. R&D investment intensity equals the ratio of R&D expenses and sales revenue.

3.1.3. The Variable Being Explained: International Competitiveness of High-Tech Industries

There is currently no clear definition of the establishment of international competitiveness indicators, and the research indicators of the international competitiveness of a specific industry by various scholars include easy-to-quantify indicators such as industrial profits, productivity, export rates, and innovation capabilities [57,58], as well as indicators that are not easy to quantify, such as corporate culture and institutional advantages [59]. In conclusion, since international competitiveness is an indicator that is difficult to evaluate clearly, studies in this area also have varied.

The international competitiveness of high-tech industries has always been a complex variable, and different scholars have defined and measured it differently. Wang [60] made a reasonable explanation for the international competitiveness of high-tech industries from the perspective of industry profitability, growth ability, and export ability. Among them, export capacity is determined by the ratio of export delivery value and sales revenue. When measuring international competitiveness, the performance of enterprises in the international market is a very important one, and the export capacity indicators can reflect the competitiveness of Chinese enterprises in the international market. Profitability, growth capacity, and export capacity are all important indicators to measure the international competitiveness of high-tech industries [61,62]. Whether in terms of market share or profitability, exports can reflect the level of competitiveness of a high-tech enterprise in the international market. Referring to Wang [37] and Wang [60], this paper uses the ratio of export delivery value to main revenue to indicate the international competitiveness of high-tech industries.

3.1.4. Control Variables

The two control variables in this paper are (1) industry size (S): the total number of high-tech enterprises in the current year is expressed, and the higher the total number of high-tech enterprises, the larger the industry scale and (2) labor productivity (L): the natural logarithm of the main business income divided by the total number of employees in high-tech enterprises in the current year.

3.2. Data Selection

The data in this paper are derived from the "China Environmental Statistics Yearbook", "China High-tech Industry Statistical Yearbook", "China Science and Technology Statistical Yearbook", "China Statistical Yearbook", etc. Export delivery values ceased to be published after 2016, data on internal expenditures of R&D funds in high-tech industries in 2017 were missing, and there were many missing data on enterprise employees in 2017. Taking into account the data integrity, the data from 2007 to 2016 in 30 provinces in China (excluding Tibet, Hong Kong, Macao, and Taiwan) are selected for analysis. In addition, Stata is used to conduct empirical testing of hypotheses.

3.3. Model Settings

3.3.1. Benchmark Regression Model

According to the above theoretical analysis, based on the theoretical analysis and research hypothesis in Section 2, this paper constructs benchmark regression models as follows.

$$T_{it} = a_0 + a_1 ER_{it} + a_2 \, LnS_{it} + a_3 \, LnL_{it} + u_i + v_t + \varepsilon_{it} \quad (1)$$

$$COM_{it} = b_0 + b_1 ER_{it} + b_2 \, LnS_{it} + b_3 LnL_{it} + u_i + v_t + \varepsilon_{it} \quad (2)$$

where T_{it} is expressed as the R&D investment of Province i in t years,

COM_{it} is expressed as the international competitiveness of Province i in t years, ER_{it} is expressed as the level of environmental regulation for Province i in t years, S_{it} and L_{it} are control variables, u_i stands for individual effect, v_t stands for time effect, ε_{it} is a random perturbation term.

3.3.2. Moderating Effect Model Construction

In order to test the moderating effect of R&D investment on environmental regulation and the international competitiveness of high-tech industries, this paper introduces the interaction between R&D investment and environmental regulation and constructs a regression model as follows.

$$COM_{it} = c_0 + c_1 ER_{it} + c_2 T_{it} + c_3 ER_{it} \times T_{it} + c_4 \, LnS_{it} + c_5 LnL_{it} + u_i + v_t + \varepsilon_{it} \quad (3)$$

where $ER_{it} \times T_{it}$ is an interaction between environmental regulation and R&D investment in Province i in t years.

4. An Empirical Analysis of the Impact of Environmental Regulations on the International Competitiveness of High-Tech Enterprises

4.1. Variable Descriptive

A descriptive statistical analysis of the variables used is shown in Table 2.

Table 2. Variable descriptive statistics.

Variables	Num	Mean	Sd	Min	Max
COM	300	0.2299002	0.2040037	0.0015504	0.7479886
CER	300	0.1721825	0.1901427	0	1
EER	300	0.255741	0.2307575	0	1
PER	300	0.2317298	0.2200453	0	0.9997382
T	300	1.484281	0.945022	0.0493274	5.268489
lnL	300	4.215964	0.4929731	2.701403	5.131347
lnS	300	5.947161	1.40616	2.639057	8.790269

As shown in Table 2, there is a large difference between the maximum and minimum values of all variables, reflecting large differences in the levels of these variables in different regions in different years.

4.2. Correlation Analysis

Table 3 is the correlation of the main variables in this paper.

Before establishing a regression model, the data should first be detected to avoid inaccuracies in the regression model. In this paper, the variance expansion factor (VIF) of the variables is diagnosed, and the VIF values of each variable are within 10, which can exclude the interference of multicollinearity. Tables 4–6 show values for each variable.

Table 3. Correlation between the main variables.

	COM	CER	EER	PER	T	lnL	lnS
COM	1.000						
CER	0.349 ***	1.000					
EER	−0.302 ***	−0.370 ***	1.000				
PER	0.494 ***	0.598 ***	−0.414 ***	1.000			
T	−0.120 **	0.139 ***	0.017	0.027	1.000		
lnL	0.291 ***	0.211 ***	−0.326 ***	0.128 **	−0.043	1.000	
lnS	0.547 ***	0.590 ***	−0.627 ***	0.688 ***	−0.008	0.385 ***	1.000

Note: ***, **represent the significance at 1% and 5%, respectively.

Table 4. Collinear analysis between variables for CER.

Variable	VIF	1/VIF
InS	1.74	0.575331
CER	1.59	0.630661
lnL	1.18	0.849891
T	1.03	0.966632
Mean VIF	1.38	

Table 5. Collinear analysis between variables for EER.

Variable	VIF	1/VIF
InS	1.75	0.569886
EER	1.67	0.597878
lnL	1.19	0.838339
T	1.00	0.997964
Mean VIF	1.41	

Table 6. Collinear analysis between variables for PER.

Variable	VIF	1/VIF
InS	2.29	0.436515
PER	1.99	0.503649
lnL	1.23	0.814992
T	1.00	0.996741
Mean VIF	1.63	

4.3. Regression Analysis

4.3.1. Environmental Regulation and R&D Investment

From Tables 7–9 regression results, it can be seen that the regression structure between environmental regulation and R&D investment, the coefficient between the two is correct, but the effect is not significant. This is inconsistent with Hypothesis H1. This shows that with the increase in the intensity of environmental regulations, high-tech enterprises will invest additional costs to cope, or the cost to some enterprises in the industrial chain will increase, resulting in an increase in the production costs of high-tech enterprises, crowding out non-productive expenditures, making the level of research and development of enterprises decrease, and the relevant scientific research and technological achievements are reduced. This is consistent with the above-mentioned "follow the cost effect". In fact, affected by some environmental protection policies, enterprises need to spend pollution control costs, pay sewage fees and machine upgrades, etc., and the production costs of enterprises increase accordingly. In the case consumer demand does not increase, enterprises are likely to face a decline in profits, thereby squeezing the innovation input of enterprises, which is not conducive to the technological innovation of enterprises. It may also be that out of long-term interests, enterprises will choose to carry out technological innovation, increase R&D investment, reduce emissions from the production process, and improve efficiency in pursuit of maximizing profits.

Table 7. Regression results for CER.

T	Coef.	Std. Err.	t	*p*
CER	0.1006422	0.2996278	0.34	0.737
LnL	−0.8710512	0.1884001	−4.62	0.000
LnS	−0.6517083	0.2008007	−3.25	0.001

Table 8. Regression results for EER.

T	Coef.	Std. Err.	t	*p*
EER	0.2714482	0.2374813	1.14	0.254
lnL	−0.8260221	0.1922337	−4.30	0.000
lnS	−0.6642553	0.2005521	−3.31	0.001

Table 9. Regression results for PER.

T	Coef.	Std. Err.	t	*p*
PER	0.0936682	0.2662542	0.35	0.725
LnL	−0.8641978	0.1897457	−4.55	0.000
LnS	−0.6590897	0.2029211	−3.25	0.001

4.3.2. Environmental Regulations and the International Competitiveness of High-Tech Enterprises

Table 10 shows that there is a significant negative correlation between EER and COM, which is consistent with Hypothesis H2b in this paper. As mentioned above, the intensity of environmental regulations is enhanced, and the cost of pollution control of enterprises increases, which may crowd out investment in research and development, production, manpower, or marketing, resulting in enterprise products in a relatively inferior position in the market. If the overall production and operation costs of the enterprise increase, it will also directly affect the profit margin of the enterprise, and the profit margin is a factor in measuring the competitiveness of the enterprise. Some companies will also offset this part of the cost by increasing prices; that is, consumers will bear the cost increase caused by environmental regulations, and under the premise that the product itself is not much improved, consumers will inevitably not pay for it, which will reduce corporate profits and weaken competitiveness. Table 11 shows a positive correlation between CER and COM, but not significantly. Table 12 shows a negative correlation between PER and COM, but not significantly. The impact of different environmental regulations on the international competitiveness of high-tech industries is inconsistent.

Table 10. EER main effect.

COM	Coef.	Std. Err.	t	*p*
EER	−0.1099742	0.0394851	−2.79	0.006
lnL	0.1775657	0.031962	5.56	0.000
lnS	0.0968447	0.033345	2.90	0.004

Table 11. CER main effect.

COM	Coef.	Std. Err.	t	*p*
CER	0.0158525	0.0504352	0.31	0.754
lnL	0.1964791	0.0317127	6.20	0.000
lnS	0.0897446	0.0338	2.66	0.008

Table 12. PER main effect.

COM	Coef.	Std. Err.	t	*p*
PER	−0.0008128	0.044827	−0.02	0.986
lnL	0.1962216	0.0319459	6.14	0.000
lnS	0.0904044	0.0341642	2.65	0.009

4.3.3. Moderating Effect Test

Table 13 shows that the coefficient of the interaction term CER*T in the model is negative and significant at a statistical level of 99%. The results show that R&D investment has a significant inhibitory effect on the influence of CER and the international competitiveness of high-tech industries. Table 14 shows that the coefficient of the interaction term EER × T in the model is positive and significant at a statistical level of 99%. The results show that R&D investment has a significant inhibitory effect on the influence of EER and the international competitiveness of high-tech industries. Table 15 shows that the coefficient of the interaction term PER × T in the model is negative and significant at a statistical level of 99%. The results show that R&D investment has a significant promoting effect on the influence of PER and the international competitiveness of high-tech industries.

Table 13. CER moderating effect.

COM	Coef.	Std. Err.	t	*p*
CER	0.294161	0.1018559	2.89	0.004
T	−0.0013927	0.0112453	−0.12	0.902
CER × T	−0.1368792	0.044029	−3.11	0.002
lnL	0.1746268	0.0324921	5.37	0.000
lnS	0.0749807	0.0338697	2.21	0.028

Table 14. EER moderating effect.

COM	Coef.	Std. Err.	t	*p*
EER	−0.2963922	0.0564257	−5.25	0.000
T	−0.0597793	0.0142116	−4.21	0.000
EER × T	0.1258927	0.0275731	4.57	0.000
lnL	0.1481809	0.0320842	4.62	0.000
lnS	0.0900635	0.0327623	2.75	0.006

Table 15. PER moderating effect.

COM	Coef.	Std. Err.	t	*p*
PER	0.3536062	0.0733275	4.82	0.000
T	0.0122013	0.0109043	1.12	0.264
PER × T	−0.2526802	0.0429924	−5.88	0.000
lnL	0.1687598	0.0312503	5.40	0.000
lnS	0.0681615	0.0327709	2.08	0.039

Therefore, R&D investment has an impact between environmental regulations and enterprise competitiveness, and from the empirical results, its effect is a moderating effect, thus, having a certain impact on the company's international competitiveness.

5. Conclusions and Recommendations

5.1. Main Conclusions

This paper mainly examines the impact of environmental regulations on the international competitiveness of high-tech industries and the moderating effect of R&D investment. Through empirical analysis, benchmark regression models and moderating effect regression models were established, and the panel data of high-tech industries and environmental

regulations in 2007–2016 of 30 provinces and cities in China (excluding Tibet, Hong Kong, Macao, and Taiwan) were analyzed, and the following conclusions were drawn.

1. The impact of China's environmental regulations on the international competitiveness of high-tech industries is related to the type of environmental regulation; only the EER has a significant and negative impact. This means that when environmental regulations are strengthened, companies may strengthen their investment in green production and pollution control, squeeze out investment in research and development, and ultimately have a negative impact on competitiveness.
2. The impact of all three types of environmental regulations on R&D investment is positive but not significant. At present, some high-tech enterprises in China are still in an immature stage, and the ability to innovate is not strong. In the face of high-intensity environmental regulations, it is often difficult to adapt through rapid technological innovation, R&D activities may be overlooked, and R&D investment cannot be significantly increased.
3. R&D investment has a significant moderating effect on the relationship between the three types of environmental regulation and the international competitiveness of high-tech industries. R&D investment has a significant inhibitory effect on the influence of CER and the international competitiveness of high-tech industries. R&D investment also has a significant inhibitory effect on the influence of EER and the international competitiveness of high-tech industries. However, R&D investment has a significant promoting effect on the influence of PER and the international competitiveness of high-tech industries.

5.2. Research Recommendations

5.2.1. Recommendations to the Government

First, governments should develop and implement regulatory policies in a targeted manner. Different regions and different industries have different development speeds and situations, so they cannot adopt a "one-size-fits-all" approach to governance but should start from the actual situation and formulate an appropriate environmental regulatory policy system. For example, for some enterprises with large energy consumption and discharge, if their emission standards are strictly limited or high pollution taxes and fees are charged, it is likely to cause enterprises to fall into development difficulties or even bankruptcy. Economic development and environmental protection should go hand in hand, and when taking certain measures to standardize environmental protection governance for enterprises, it should be ensured that enterprises can have a buffer period for a period of time and gradually transform. Developing countries should raise the threshold of entry for dirty industries, control exports of pollution and energy-intensive industries, or develop new export competitive advantages [63].

Second, adopt flexible environmental regulatory measures, combine different environmental regulatory measures, and give full play to the advantages of various environmental regulatory measures. China's current policies are mostly command and control type, the initiative and autonomy of enterprises are not high, and the policy is relatively single, so it is difficult to play the best effect of the policy. The government should fully mobilize the enthusiasm of enterprises for green innovation and enable enterprises to take the initiative to implement environmental supervision measures, give play to the effect of the Porter hypothesis of environmental regulation, and force enterprises to upgrade their technology. Of course, in addition to the flexibility of environmental protection regulations, there must also be strict legal provisions to resolutely put an end to the fluke psychology of some enterprises. At the same time, guide the industry to carry out the green transformation, organize some successful transformation enterprises to share experience, and provide a reference for enterprises. In addition, the implementation of specific environmental regulation executive orders should pay attention to the differences in policy effects brought about by regional factors.

Finally, increase support and assistance for the technological innovation activities of enterprises. At present, in China's high-tech enterprises, R&D compared with developed countries, the level of investment intensity is still not high, on the one hand, due to the low awareness of scientific and technological innovation of enterprises, on the other hand, because enterprises do not have enough capital investment. Considering that there is a positive correlation between R&D investment and competitiveness, the government should take appropriate measures to help enterprises improve their scientific research capabilities, such as increasing tax incentives for high-tech enterprises, subsidizing R&D investment of enterprises, and encouraging the introduction of outstanding talents.

5.2.2. Recommendations for High-Tech Enterprises

First, raise awareness of environmental protection further. Enterprises are individuals in society, and protecting the environment has gradually become a consensus, and green production has become a development trend. As an important part of the national economy, high-tech enterprises should take the initiative to pursue green development, firmly implement relevant policies, and cooperate with environmental regulations. At the same time, increase capital investment in environmental protection. Enterprises that increase their investment in environmental protection are making a long-term investment in the development of enterprises themselves. From this point of view, environmental regulation can avoid some economic losses for enterprises. From the perspective of corporate marketing, publicizing the company's environmental protection measures to the public is conducive to establishing a positive company image among the public and has a profound impact on brand development.

Second, continue to increase investment in scientific and technological research and development. In the short term, increasing the R&D investment of enterprises will increase the cost to enterprises and have an impact on profitability, but scientific research investment is a long-term work, and its positive impact will inevitably be reflected in the improvement in production efficiency, the leading position in the product market, and the reduction in pollution emissions of enterprises so that enterprises have a longer buffer time in the face of environmental regulations. In addition, through scientific research investment, the pollution control technology of enterprises and the production process will be improved. At the same time, new breakthroughs in green technology will be achieved and promote the transformation of industrial structures in the green direction.

Finally, enhance the awareness of international competition among enterprises. Global integration is the development trend of today's world; all enterprises should take a longer-term view. Although China has a large population and a huge market, if one only looks at the present, the market is likely to be crowded. As a high-tech enterprise, it is even more important to consider the world as the target market, use world-renowned enterprises as the benchmark, go out of the country, compete with international high-end brands, and continue to develop and progress in the fierce market competition.

5.3. Research Deficiencies and Prospects

In this paper, a single indicator, the export ability of enterprises, is used to measure the international competitiveness of high-tech industries. There are certain deficiencies, and subsequent research can be more in-depth and use diversified measurement indicators. This paper studies the international competitiveness of the entire high-tech industry. It is also necessary to subdivide high-tech industries if a sufficient sample is available. So that more accurate recommendations can be made on a case-by-case basis to improve the international competitiveness of the high-tech industries.

Author Contributions: Conceptualization, R.S.; methodology, R.S. and W.T.; formal analysis, W.T.; investigation, W.T.; data curation, R.S.; writing—original draft preparation, R.S. and W.T.; writing—review and editing, W.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the MOE (Ministry of Education in China) Project of Humanities and Social Sciences (Grant Numbers:18YJA630105).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are available from the authors upon reasonable request as the data need further use.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Sun, H.P.; Kporsu, A.K.; Taghizadeh-Hesary, F.; Edziah, B.K. Estimating environmental efficiency and convergence: 1980 to 2016. *Energy* **2020**, *208*, 118224. [CrossRef]
2. Cai, L.; Sampene, A.K.; Khan, A.; Fredrick, O.A.; Tu, W.J.; Robert, B. Does Entrepreneur Moral Reflectiveness Matter? Pursing Low-Carbon Emission Behavior among SMEs through the Relationship between Environmental Factors, Entrepreneur Personal Concept, and Outcome Expectations. *Sustainability* **2022**, *14*, 808. [CrossRef]
3. Yoshida, F. High-tech pollution. *Econ. J. Hokkaido Univ.* **1994**, *23*, 73–138.
4. Chiu, H.M. The dark side of Silicon Island: High-tech pollution and the environmental movement in Taiwan. *Capital. Nat. Social.* **2011**, *22*, 40–57. [CrossRef]
5. Yuan, X.L.; Shi, S.; Li, C.J. Can Environmental Regulation Promote Innovation? *Stat. Inf. Forum* **2021**, *10*, 77–85.
6. Porter, M.E.; Linde, C.V.D. Toward a New Conception of the Environment-Competitiveness Relationship. *J. Econ. Perspect.* **1995**, *9*, 97–118. [CrossRef]
7. Wang, W.P. Environmental regulation, spatial spillover and regional industrial competitiveness. *Chin. Mouth Resour. Environ.* **2013**, *23*, 123–130.
8. Porter, M.E. *Competitive Strategy: Techniques for Analyzing of Industries and Competitions*; Free Press: New York, NY, USA, 1998.
9. Greenstone, M.; List, J.A.; Syverson, C. *The Effects of Environmental Regulation on the Competitiveness of U.S. Manufacturing*; NBER: Cambridge, MA, USA, 2012.
10. Nath, P.; Ramanathan, R. Environmental management practices, environmental technology portfolio, and environmental commitment: A content analytic approach for UK manufacturing firms. *Int. J. Prod. Econ.* **2016**, *171*, 427–437. [CrossRef]
11. Fu, J.Y.; Li, L.S. An empirical study on environmental regulation, factor endowment and international competitiveness of the industry—Based on panel data from China's manufacturing industry. *Manag. World* **2010**, *10*, 87–98, 187.
12. Dong, M.J. *The Impact of Environmental Regulation on the International Competitiveness of Chinese Industries*; Graduate School of Chinese Academy of Social Sciences: Beijing, China, 2011.
13. Sun, R.H.; Xiong, Y.L. The impact of environmental regulation on the export competitiveness of China's manufacturing industry. *J. China Univ. Pet. Soc. Sci. Ed.* **2019**, *35*, 28–36.
14. Gray, W.B.; Shadbegian, R.J. Plant vintage, technology, and environmental regulation. *J. Environ. Econ. Manag.* **2003**, *46*, 384–402. [CrossRef]
15. Bel, G.; Joseph, S. Policy stringency under the European Union Emission trading system and its impact on technological change in the energy sector. *Energy Policy* **2018**, *117*, 434–444. [CrossRef]
16. Yang, Q.Z.; Otsuki, T.; Michida, E. Product-Related Environmental Regulation, Innovation, and Competitiveness: Empirical Evidence from Malaysian and Vietnamese Firms. *Int. Econ. J.* **2020**, *34*, 510–533. [CrossRef]
17. Pitelis, A.; Vasilakos, N.; Chalvatzis, K. Fostering innovation in renewable energy technologies: Choice of policy instruments and effectiveness. *Renew. Energy* **2020**, *151*, 1163–1172. [CrossRef]
18. Brunnermeier, S.B.; Cohen, M.A. Determinants of Environmental Innovation in US Manufacturing Industries. *J. Environ. Econ. Manag.* **2003**, *45*, 278–293. [CrossRef]
19. Tang, K.; Qiu, Y.; Zhou, D. Does Command-and-Control Regulation Promote Green Innovation Performance? Evidence from China's industrial enterprises. *Sci. Total Environ.* **2020**, *712*, 136362. [CrossRef]
20. Liu, Y.Q.; Zhu, J.L.; Li, E.Y.; Meng, Z.Y.; Song, Y. Environmental regulation, green technological innovation, and eco-efficiency: The case of Yangtze River economic belt in China. *Technol. Forecast. Soc. Chang.* **2020**, *155*, 119993. [CrossRef]
21. Wang, W.D.; Wang, D.; Ni, W.L.; Zhang, C.J. The impact of carbon emissions trading on the directed technical change in China. *J. Clean. Prod.* **2020**, *272*, 122891. [CrossRef]
22. Li, M.Y.; Zhang, J.S.; Ramanathan, R.; Li, R.Q. Opening the Black Box: The Impacts of Environmental Regulations on Technological Innovation. *Int. J. Environ. Res. Public Health* **2020**, *17*, 4365. [CrossRef]
23. Wang, L.F. *Competition and the Choice of Innovative Behavior of Enterprises*; University of International Business and Economics: Beijing, China, 2018.
24. Sun, X.M.; Wang, J. The impact of environmental regulation on the distribution of Chinese enterprises. *China's Ind. Econ.* **2014**, *12*, 44–56.
25. Palmer, K.; Oates, W.E.; Portney, P.R. Tightening Environmental Standards. The Benefit-Cost or the No-Cost Paradigm? *J. Econ. Perspect.* **1995**, *9*, 119–132. [CrossRef]

26. Kemp, R.; Pontoglio, S. The innovation effects of environmental policy instruments: A typical case of the blind men and the elephant? *Ecol. Econ.* **2011**, *72*, 28–36. [CrossRef]
27. Zhang, C.Y. Science and technology standard environmental regulation and enterprise export dynamics—A natural experiment based on cleaner production standards. *Int. Trade Issues* **2019**, *12*, 32–45.
28. Zheng, T.D.; Bai, X.L. Environmental regulation and re-examination of international competitiveness of industries from the perspective of dynamic evolution game. *Ind. Econ. Rev.* **2019**, *10*, 70–86.
29. Jaffe, A.B.; Peterson, S.R.; Portney, P.R.; Stavins, R.N. Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us? *J. Econ. Lit.* **1995**, *33*, 132–163.
30. Kneller, R.; Manderson, E. Environmental Regulations and Innovation Activity in UK Manufacturing Industries. *Resour. Energy Econ.* **2012**, *34*, 211–235. [CrossRef]
31. Sun, H.P.; Clottey, S.A.; Geng, Y.; Fang, K.; Amissah, J.C.K. Trade Openness and Carbon Emissions: Evidence from Belt and Road Countries. *Sustainability* **2019**, *11*, 2682. [CrossRef]
32. Hu, W.; Wang, D. How does Environmental Regulation Influence China's Carbon Productivity? An Empirical Analysis Based on the Spatial Spillover Effect. *J. Clean. Prod.* **2020**, *257*, 120484. [CrossRef]
33. Tang, H.L.; Liu, J.M.; Wu, J.G. The impact of command-and-control environmental regulation on enterprise total factor productivity: A quasi-natural experiment based on China's "Two Control Zone" policy. *J. Clean. Prod.* **2020**, *254*, 120011. [CrossRef]
34. Wang, Q.; Ren, S.G.; Hou, Y. Atmospheric environmental regulation and industrial total factor productivity: The mediating effect of capital intensity. *Environ. Sci. Pollut. Res.* **2020**, *27*, 33112–33126. [CrossRef]
35. Santis, D.R.; Lasinio, C.J. Environmental policies, innovation and productivity in the EU. *Glob. Econ. J.* **2015**, *51*, 249–262. [CrossRef]
36. Lu, Y. Environmental pollution from an open macro perspective: A review. *Econ. Res. J.* **2012**, *47*, 146–158.
37. Wang, G.Y.; Wang, D. Porter Hypothesis, Environmental Regulation and Enterprise Technological Innovation: A Comparative Analysis of Central and Eastern China. *China Soft Sci.* **2011**, *1*, 100–112.
38. Shen, N. The threshold effect of environmental regulation on the impact of regional technological innovation. *Chin. Mouth Resour. Environ.* **2012**, *22*, 12–16.
39. Li, G.Q.; Fang, X.B.; Zhao, N. Are environmental regulations inhibiting the export competitiveness of high-tech industries?—Empirical analysis based on threshold effect. *J. Chongqing Technol. Bus. Univ. Soc. Sci. Ed.* **2021**, *2021*, 1–19.
40. Pandit, S.; Wasley, C.E.; Zach, T. The Effect of Research and Development (R&D) Inputs and Outputs on the Relation between the Uncertainty of Future Operating Performance and R&D Expenditures. *J. Account. Audit. Financ.* **2014**, *26*, 121–144.
41. Yang, C.H.; Tseng, Y.H.; Chen, C.P. Environmental Regulations, Induced R&D, and Productivity: Evidence from Taiwan. *Resour. Energy Econ.* **2012**, *34*, 514–532.
42. Petroni, G.; Bigliardi, B.; Galati, F. Rethinking the Porter Hypothesis: The Underappreciated Importance of Value Appropriation and Pollution Intensity. *Rev. Policy Res.* **2018**, *36*, 121–140. [CrossRef]
43. He, W.J.; Tan, L.M.; Liu, J.; Zhang, H.X. Property rights protection, environmental regulation and corporate financial performance: Revisiting the Porter Hypothesis. *J. Clean. Prod.* **2020**, *264*, 121615. [CrossRef]
44. Chang, K.H.; Gotcher, D.F. How and when does co-production facilitate eco-innovation in international buyer-supplier relationships? The role of environmental innovation ambidexterity and institutional pressures. *Int. Bus. Rev.* **2020**, *29*, 101731. [CrossRef]
45. Javeed, S.A.; Latief, R.; Lefen, L. An analysis of relationship between environmental regulations and firm performance with moderating effects of product market competition—Empirical evidence from Pakistan. *J. Clean. Prod.* **2020**, *254*, 120197. [CrossRef]
46. Du, L.Z.; Zhao, Y.H.; Tao, K.T.; Lin, W.F. The compound effect of environmental regulation and governance transformation on the improvement of green competitiveness: Based on the empirical evidence of Chinese industry. *Econ. Res. J.* **2019**, *10*, 106–120.
47. Zhou, Q.; Zhang, X.; Shao, Q.; Wang, X. The non-linear effect of environmental regulation on haze pollution: Empirical evidence for 277 Chinese cities during 2002–2010. *J. Environ. Manag.* **2019**, *248*, 109274. [CrossRef]
48. Low, P.; Yeats, A. *Do "Dirty" Industries Migrate*; World Bank Discussion Paper No. 159; World Bank: New York, NY, USA, 1992.
49. Levinson, A. Environmental regulations and manufacturers' location choices: Evidence from the census of manufactures. *J. Public Econ.* **1996**, *62*, 5–29. [CrossRef]
50. Cole, M.A.; Elliot, R.J.; Wu, S.S. Industrial activity and the environment in China: An industry-level analysis. *China Econ. Rev.* **2008**, *19*, 393–408. [CrossRef]
51. Ben Kheder, S.; Zugravu-Soilita, N. *The Pollution Haven Hypothesis: A Geographic Economy Model in a Comparative Study*; FEEM Working Paper; FEEM: Milan, Italy, 2008.
52. Cole, M.A.; Elliott, R.J.; Fredriksson, P. Endogenous pollution havens: Does FDI influence environmental regulations. *Scadinavian J. Econ.* **2008**, *108*, 157–178.
53. Sauter, C. *How Should We Measure Environmental Policy Stringency? A New Approach*; IRENE Working Paper No. 14-01; IRENE: Neuchâtel, Switzerland, 2014.
54. Song, D.Y.; Yang, Q.Y. The role of environmental regulation and human capital in breaking the resource curse. *Urban Issues* **2019**, *9*, 62–73.
55. Luo, Y.S.; Salman, M.; Lu, Z.N. Heterogeneous impacts of environmental regulations and foreign direct investment on green innovation across different regions in China. *Sci. Total Environ.* **2021**, *759*, 143744. [CrossRef]

56. Yang, X.D.; Wang, D. Heterogeneous environmental regulation, foreign direct investment, and regional carbon dioxide emissions: Evidence from China. *Sustainability* **2022**, *14*, 6386. [CrossRef]
57. Jiang, A.L. Export evaluation method: An important means to evaluate international competitiveness. *J. Theory* **2004**, *2*, 66–68.
58. Zhang, J.C. *Theories and Methods of International Competitiveness Evaluation*; Economic Science Press: Beijing, China, 2002.
59. Zhang, W.D. *Research on the International Competitiveness and Influencing Factors of Chinese and US Internet Enterprises*; Shandong University: Jinan, China, 2020.
60. Wang, T. *A Comparative Study on the International Competitiveness of High-Tech Enterprises*; Zhejiang University of Technology: Hangzhou, China, 2012.
61. Gao, H.L. *Measurement and Comparative Study of International Competitiveness of Manufacturing Industry*; Beijing Forestry University: Beijing, China, 2020.
62. Li, J.M.; Zhang, J.Z. Research on the impact of environmental regulation on the international competitiveness of pollution-intensive industries in China. *Shanxi Agric. Econ.* **2020**, *15*, 35–38.
63. Sun, H.P.; Edziah, B.K.; Song, X.Q.; Kporsu, A.K.; Farhad, T.H. Estimating Persistent and Transient Energy Efficiency in Belt and Road Countries: A Stochastic Frontier Analysis. *Energies* **2020**, *13*, 3837. [CrossRef]