

Article

Does Environmental Regulation Promote Eco-Innovation Performance of Manufacturing Firms?—Empirical Evidence from China

Jieqiong Wang ¹, Shichao Hu ^{2,*} and Ziyi Zhang ²¹ Shenzhen Institute of Information Technology, Shenzhen 518000, China² School of Accounting, Jiangxi University of Finance and Economics, Nanchang 330013, China

* Correspondence: hushichao@jxufe.edu.cn

Abstract: As the world becomes more concerned about carbon emissions, the Chinese government, which is a large contributor to carbon emissions, has also begun to pay attention to the issue of carbon emissions. Environmental regulatory policies have been implemented to improve the environment, but are these policies really conducive to improving firms' eco-innovation performance? This paper empirically investigates the relationship between environmental regulation policies and firms' eco-innovation performance in China and finds that: firstly, environmental regulation in China is inadequate and that manufacturing eco-innovation performance is generally low; secondly, there is a U-shaped relationship between environmental regulation policies and firms' eco-innovation performance; thirdly, there is significant industry and regional heterogeneity in the induced effects of environmental regulation tools; and fourthly, there is a mediating effect of industrial agglomeration on the promotion of firms' eco-innovation performance. The conclusions of this paper are: firstly, that the Chinese government should continue to improve environmental regulations and strictly enforce them so that green becomes the colour of 'economic recovery'; secondly, that the Chinese government should develop scientific and reasonable environmental regulatory policies according to local conditions; thirdly, that Chinese companies should increase their spending on research and development; and fourthly, that the Chinese government needs to optimise the industrial layout and support mechanisms. The Chinese government should play an active role in industrial agglomeration in technological innovation.

Keywords: environmental regulation; manufacturing industry; eco-innovation performance



Citation: Wang, J.; Hu, S.; Zhang, Z. Does Environmental Regulation Promote Eco-Innovation Performance of Manufacturing Firms?—Empirical Evidence from China. *Energies* **2023**, *16*, 2899. <https://doi.org/10.3390/en16062899>

Academic Editor: Chiara D'Alpaos

Received: 24 February 2023

Revised: 16 March 2023

Accepted: 18 March 2023

Published: 21 March 2023



Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The comprehensive promotion of green development is a vital component of the new global development concept, a critical force for achieving high-quality development, and a key factor in constructing a beautiful society. However, green recovery or high-quality development in the post-epidemic era cannot rely on factor-driven innovation but must instead rely on environmentally friendly technological innovation [1]. As providers of market goods or services, enterprises can only effectively reduce their impact on the ecological environment if they implement green technologies throughout their production and operation processes. However, the multiple externalities of green technology innovation, the unpredictability of technology, the unpredictability of the market, and the imperfection of the management system have led to a lack of innovation, motivation, and capability. To minimise the negative impact of enterprise production on the environment, resources, and society, the government has adopted a series of administrative, legal, and economic environmental regulatory instruments that have yielded specific short-term results [2]. One of the goals of environmental regulation is to improve the environment, and incentivising companies to innovate in green technologies is a crucial means of achieving this goal.

In light of this, this paper examines the cause-and-effect relationship between China's environmental regulation policies and corporate eco-innovation performance.

There are four general perspectives regarding the relationship between environmental regulation and innovation in green technology. Firstly, according to the Porter hypothesis, several studies indicate that stricter environmental regulations facilitate the development of green technologies [3–5]. Secondly, some scholars argue, from a neoclassical economics perspective, that environmental regulation increases firm costs and, as a result, consistently inhibits firms' green technology innovation activities [6–9]. Thirdly, some studies contend that there is a nonlinear relationship between environmental regulation and technological advancement due to changes in time scales, i.e., in relation to pollution control in the short term [10–15]. Finally, by analysing the calculation results, some empirical studies have concluded that there is no significant relationship between the two [16–20]. In general, the perspectives presented in recent studies are derived from the four aforementioned foundational perspectives and are typically only used to explain the interrelationship in specific contexts.

Previous scholarly research has focused on the relationship between environmental regulation and firms' eco-innovation behaviour. In contrast, more research needs to be conducted on the effect of environmental regulation on firms' eco-innovation performance. Whether a company chooses to eco-innovate depends on whether eco-innovation can benefit the company. If environmental regulations become more stringent, firms can benefit from eco-innovation. Then, firms that engage in eco-innovation will benefit from increased environmental regulation stringency. Therefore, it is necessary to investigate the connection between environmental regulation and the eco-innovation performance of enterprises [21].

What is eco-innovation performance? Scholars have yet to reach a consensus as to how to define eco-innovation performance and how to measure the indicator. The currently most accepted definition is the assessment of the balance between the cost of an enterprise's eco-innovation technology inputs and the benefits generated in the pursuit of both economic and environmental win-win, with the sustainable development of the enterprise as the goal. This clearly differs from technological innovation in the pure pursuit of economic benefits and technological innovation in the pursuit of environmental benefits. Therefore, in measuring this indicator, appropriate indicators reflecting both economic and environmental aspects need to be selected to measure innovation performance [22].

With regard to the impact of environmental regulation on the eco-innovation performance of enterprises, some scholars studied the impact of command-and-control environmental regulation tools and market-incentive environmental regulation tools on the performance of green technology innovation in 30 Chinese provinces, cities, and districts based on the perspective of policy differentiation and found that either environmental regulation tool significantly incentivises the performance of green product innovation and process innovation. However, scholars differ in their views on which instrument is more effective; some scholars found that environmental taxes and emission standards have a higher incentive effect than command-based environmental regulation instruments [23,24]. Others argue that the effects of imperative environmental regulation tools are more pronounced and dynamic [25–27]. Scholars have also studied the heterogeneity of environmental regulation tools and found that in the eastern region, incentive-based effects are more pronounced, whereas in the central and western regions, command-based effects are more pronounced [28–30].

Although scholars have begun to focus on the relationship between environmental regulation and firms' eco-innovation performance and have conducted some research, these studies are still shallow, and the degree of empirical evidence is not deep enough, nor do they explain well how to measure the level of firms' eco-innovation performance. When measuring the level of eco-innovation performance of firms, there is little literature that integrates economic performance with environmental performance. Most existing studies have been conducted in industries with high energy consumption and pollution; studies on manufacturing subsectors are lacking, and the impact of different types of environmental

regulation has not been sufficiently differentiated. The research presented in this paper helps to fill these gaps.

In this paper, we develop several econometric models by matching information from the Database of Chinese Industrial Enterprises and the Database of Pollution Emissions from Chinese Industrial Enterprises. This primary research elements presented in this paper are as follows: (1) In this paper, we measure the level of eco-innovation performance of Chinese industrial enterprises and examine their current situation and problems. (2) We empirically test the relationship between different types of environmental regulatory policies and the eco-innovation performance of enterprises. (3) We examine whether there is industry heterogeneity and geographical heterogeneity in the policy effects of different types of environmental regulatory interventions (including command and market-based interventions). (4) We empirically test the mediating effect of environmental regulatory policies on enterprises' eco-innovation performance. (5) Finally, we conduct robustness tests on the empirical results and propose policy recommendations.

The innovations of this paper are as follows: (1) The causal relationship between corporate eco-innovation performance and environmental regulation is investigated, contributing to the theoretical study of corporate eco-innovation performance. (2) The relationships between different environmental regulation policy instruments and corporate eco-innovation performance, their effects, and transmission paths are studied separately, which helps to formulate government policies. (3) The consequences of environmental regulation policy instruments in various industries and regions are innovatively studied, including the intermediary paths through which environmental regulation policies influence corporate eco-innovation performance, which is beneficial for the government's targeted policy formulation.

2. Literature Review and Theoretical Background

2.1. Eco-Innovation Performance and Environmental Regulation

Since the beginning of the industrial era, the pollution and emissions resulting from human activities, particularly industrial production, have exerted significant pressure on the ecological environment. A proportion of 20% of the Earth's surface has been significantly degraded by human activity, and an estimated 60% of the planet's ecosystems have been destroyed, according to the 2019 Yearbook of the United Nations Environment Programme. Environmental issues have garnered worldwide attention, and the role of innovation has risen to the forefront as a consequence [31], resulting in the rise of several concepts, such as environmental technology innovation, environmental innovation, green innovation, sustainable innovation, and eco-innovation. These concepts are similar in that they all refer to new or significantly improved behaviours in products (or services), production processes, market approaches, organisational structures, or institutional arrangements that can result in environmental improvements compared to other options [32]. Given that international organisations such as the European Union and the OECD (Organization for Economic Cooperation and Development) have conducted the most systematic research under the name "eco-innovation performance", there is a growing tendency for academics to generalise the results of research in this field under the name "eco-innovation". Yang, L. and Hamori, S. (2021) [33] introduced the concept of "eco-innovation" in the mid-1990s, defining it as technologies that can significantly reduce the negative environmental impact of production and consumption processes. Eco-innovation is not fundamentally distinct from general innovation in terms of its process. It also entails research, development, pilot production, production, dissemination, and their interaction, as well as technological, organisational, and institutional changes, with the exception that eco-innovation can result in improved environmental performance. The recognised externalities of environmental problems make it possible for different instruments of environmental regulation to have different effects on different types or even stages of eco-innovation, with some effects acting as catalysts and others as impediments. The relationship between environmental regulation and corporate eco-innovation is complex due to these distinct effects [34].

It is challenging to solve the problem of insufficient incentives for eco-innovation through market forces alone because eco-innovation is not the primary objective of business production and operation and because enterprises bear the full cost of eco-innovation but cannot monopolise its benefits [35]. Therefore, the government must incentivise eco-innovation and encourage it through coercion. Environmental regulations have both positive and negative effects on eco-innovation in business. The negative impact, i.e., the “crowding-out effect”, refers to the intensity of environmental regulations that will increase the cost of enterprises’ pollution emissions. As a result, enterprises tend to increase their pollution control investment to avoid high penalty costs, thereby crowding out their innovation resources and inhibiting their eco-innovation [35]. The positive impact, i.e., the “compensation effect”, refers to the increase in the intensity of environmental regulations that will cause the cost of enterprise pollution treatment and penalties to be greater than the input of enterprise technological innovation, compelling high-pollution and high-energy-consuming enterprises to undertake eco-innovation activities [36]. The positive and negative effects of environmental regulation on enterprises are not synchronised, as the negative effect of “compliance cost” is frequently generated in the current period [37]. However, the positive effect of “innovation compensation” is frequently observed in the long term, resulting in a “U”-shaped trajectory between environmental regulation and eco-innovation performance. Thus, the relationship between environmental regulation and eco-innovation performance follows a U-shaped trajectory. Consequently, in this paper, we propose hypothesis 1 as follows:

H₁: *There is a “U”-shaped relationship between environmental regulations and firms’ eco-innovation performance.*

2.2. Industry and Regional Heterogeneity of Environmental Regulatory Instruments

China has strengthened its understanding and protection of the ecological environment in the governance process since 1949 [38]. China’s environmental regulation policy can be roughly divided into three phases: the exploration phase (1949–2006), based on the introduction of laws and regulations; the implementation phase (2007–2011), based on government performance assessment; and the enhancement phase (2012–present), based on a combination of administrative command and market-based environmental regulation policies. In this paper, we argue that there are significant differences between the effects of command-based and market-based regulatory policies on corporate eco-innovation based on the respective strengths and weaknesses of command-based and market-based regulatory policies.

Figure 1 summarises the mechanism of action, pathways, and conditions of market-based and command-based environmental regulatory instruments that encourage firms to engage in eco-innovation. Regarding the mechanism of action, policy instruments must be effectively transmitted to firms and generate substantial cost pressure or economic incentives to induce firms to ultimately engage in innovative activities. Regarding transmission paths, market-based instruments increase firms’ costs by inducing exogenous energy price markups. In contrast, command-based instruments increase firms’ costs at both the policy objective and implementation levels. Regarding the action conditions, on the one hand, market-based instruments are effectively transmitted by regulating the energy price market. Command-based instruments are likely to ensure the effectiveness of policy implementation through the evaluation of state-owned enterprises. On the other hand, high energy costs and difficulty in cost passthrough are the conditions that increase cost pressure or economic incentives [39]. Due to industry-specific differences in action conditions, there is the potential for heterogeneity in the effects of market-based or command-based environmental regulations in inducing innovation across industries and geographic regions.

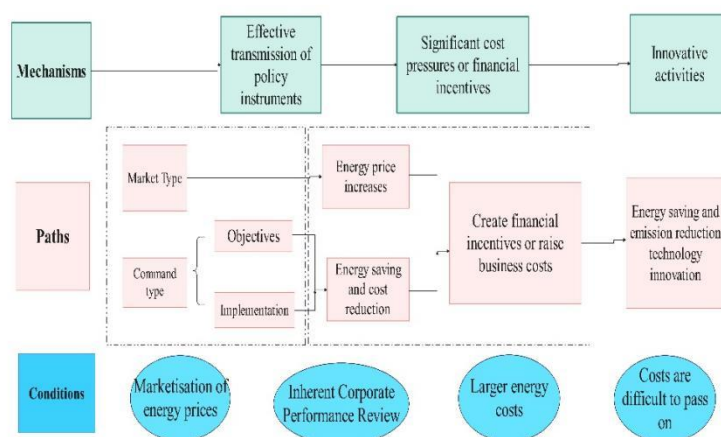


Figure 1. Mechanisms of action of market-based and command-based policy instruments to induce eco-innovation.

Therefore, in this paper, we propose hypotheses 2 and 3 as follows:

H₂: *There is heterogeneity in the induced innovation effect of environmental regulation tools among industries.*

H₃: *There is heterogeneity in the induced innovation effect of environmental regulation tools among regions.*

2.3. Industrial Clustering with Eco-Innovation Performance

The implementation and strengthening of environmental regulations result in increased operating costs and burdens for enterprises, especially polluting enterprises, which are more likely to relocate to regions with less stringent environmental regulations [40], resulting in industrial shifts and a decrease in industrial agglomeration in the original regions. Simultaneously, moderate industrial agglomeration can result in the spatial concentration of factor resources and provide abundant human and material support and assistance for enterprise technological innovation. This is conducive to forming industrial specialisation and economies of scale [41], which increase labour productivity and free up time and enterprises for technological research, development, and collaboration [42]. It encourages enterprise resource sharing, facilitating information exchange, R&D collaboration, and cost savings, thereby accelerating technological diffusion and spillover. Environmental regulation influences technological innovation and industrial concentration, and industrial concentration also influences technological innovation. Environmental regulations have both direct and indirect effects on technological innovation of effects via industrial concentration. On the one hand, environmental regulations can harm technological innovation due to the “crowding-out effect”. On the other hand, they can force enterprises to improve the technological innovation of their products or production processes through the “compensation effect” of technological innovation to meet emission standards and reduce the cost of emissions [43]. On the other hand, some enterprises may relocate to industrial agglomerations to enhance technological innovation through resource sharing, economies of scale, and technology spillover effects to comply with environmental regulations.

Therefore, in this paper, we propose hypotheses 4 and 5 as follows:

H₄: *Industrial agglomeration has an impact on enterprises’ eco-innovation.*

H₅: *Industrial agglomeration has a mediating effect on environmental regulation to promote technological innovation.*

3. Research Design

3.1. Solutions and Comparative Statistics

1. Models

In this paper, we compare the effects of command-based environmental regulation versus market-based environmental regulation instruments on the eco-innovation performance of firms using the following model:

$$EIP_{it} = \alpha_i + \beta_1 ERC_{it} + \beta_2 ERC_{it}^2 + \beta_3 InHCl_{it} + \beta_4 ES_{it} + \beta_5 EO_{it} + \varepsilon_{it}$$

$$EIP_{it} = \lambda_i + \theta_1 ERM_{it} + \theta_2 ERM_{it}^2 + \theta_3 InHCl_{it} + \theta_4 ES_{it} + \theta_5 EO_{it} + \delta_{it}$$

where EIP_{it} represents the eco-innovation performance of industry i in year t , and ERC_{it} and ERM_{it} represent the intensity of command-based and market-based environmental regulation tools in industry i in year t , respectively. In this paper, human capital (HCl_{it}), enterprise size (ES_{it}), and economic openness (EO_{it}) are the control variables. The main body and core of eco-innovation activities is talent, and the higher the level of human capital, the more technological innovation can be promoted; the larger the enterprise, the greater the advantage of capital and talent and the more technical support can be provided to guarantee eco-innovation. Nonetheless, the larger the scale, the greater the investment in fixed assets, such as equipment, and the slower the cost and innovation of technological renewal; the introduction of foreign capital can bring financial and talent support, which enables domestic enterprises to engage in eco-innovation activities. At the same time, introducing foreign investors is conducive to strengthening domestic industry competition and encouraging domestic enterprises to increase their innovation investment. i, t are denoted as the intercept terms under individual effects; $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \theta_1, \theta_2, \theta_3, \theta_4,$ and θ_5 are the parameters to be estimated; ε_{it} and δ_{it} are the random error terms.

2. Variables

Explained variables (EIP_{it}): Scholars have not developed a unified eco-innovation performance evaluation index until now. Most of the existing literature constructs this evaluation index from an input–output perspective, which has the benefit of promptly reflecting the relevance of the input–output ratio in the enterprise innovation process. Human, financial, and material resources are the most fundamental factors of production from an input perspective. The expenditure of money is the assurance of financial resources, whereas human resources are the foundation. National policy also influences the innovation behaviours of enterprises. In terms of output indicators, the number of patent applications and new product sales revenue is the most typical. The number of patent applications can reflect enterprises' scientific research and innovation achievements. In contrast, new product sales revenue can reflect the level of marketability of new products produced by enterprises utilising new technologies. In this paper, we develop an index system for evaluation of the eco-innovation performance of enterprises based on an input–output perspective; the index system's specific components are detailed in Table 1.

How to measure performance is an essential concept. Domestic and international performance measurement techniques include stochastic frontier analysis (SFA), data envelopment analysis (DEA), and the projection-seeking (PP) model, among others. The first two methods are currently the most popular but have glaring flaws. When dealing with high-latitude data, the PP model can find the optimal projection direction to reflect the original data to the greatest extent possible, then reduce the data to a low-dimensional space for subsequent processing and analysis. Given that the evaluation of eco-innovation performance involves multidimensional input and output data, the PP model is used to evaluate performance in this paper. According to the projection-tracing model's calculation rules, the optimal projection values for 28 industries in 2011–2020 can be determined (We have categorised China's industrial enterprises into 28 industries, with the 28 industries being divided as shown in Table 2). The greater the optimal projection value, the greater

the industry's eco-innovation performance. Figure 2 displays the final eco-innovation performance values calculated for each industry by the PP model.

Table 1. Eco-innovation performance evaluation index system.

Tier 1 Indicators	Tier 2 Indicators	Tier 3 Indicators	Unit	Indicator Type
Eco-innovation input	R & D investment	R & D staff (A_1)	People	+
		R & D staff (A_2)	Million CNY	+
	Investment in pollution control	Environmental pollution treatment investment amount (A_3)	Million CNY	+
Eco-innovation output	Economic benefit output	New product sales revenue (A_4)	Million CNY	+
		Total assets contribution ratio (A_5)	%	+
		Number of patent applications (A_6)	Pieces	+
		R & D output level (A_7)	-	+
	Environmental benefit output	Industrial wastewater discharge (A_8)	Million tons	-
		Industrial waste gas emissions (A_9)	Billion cubic meters	-
		General industrial solid waste generation (A_{10})	Million tons	-
		General industrial solid waste generation (A_{11})	%	+
		Comprehensive energy consumption per unit of industrial output value (A_{12})	Million t standard/billion CNY	-

Note: "+" represents benefit-based indicators, and "-" represents cost-based indicators.

Table 2. Manufacturing industry segmentation categorization.

Number	Segmentation	Number	Segmentation
1	Agricultural and sideline food processing industry	15	Pharmaceutical manufacturing
2	Food manufacturing	16	Chemical fiber manufacturing
3	Wine, beverage, and refined tea manufacturing	17	Rubber and plastic products industry
4	Tobacco product industry	18	Non-financial mineral products industry
5	Textile industry	19	Ferrous metal smelting and rolling industry
6	Textile and apparel industry	20	Non-ferrous metal smelting and rolling industry
7	Leather, fur, feathers (and their products), and footwear industry	21	Metal products industry
8	Wood processing and wood, bamboo, rattan, palm, and grass products industry	22	General equipment manufacturing
9	Furniture manufacturing	23	Specialised equipment manufacturing
10	Paper and paper products industry	24	Transportation equipment manufacturing
11	Printing and recording media reproduction industry	25	Electrical machinery and equipment manufacturing
12	Culture, education, industry, sports, and recreational goods manufacturing	26	Computer, communications, and other electronic equipment manufacturing
13	Oil, coal, and other fuel processing industries	27	Instrument manufacturing
14	Chemical raw materials and chemical product manufacturing	28	Other manufacturing industries

Figure 2 demonstrates that the eco-innovation performance levels of Chinese manufacturing enterprises are all low. There is evident industry heterogeneity, with higher eco-innovation performance values in industries with strong technology and lower eco-innovation performance values in resource-based industries. The mean eco-innovation performance values of each industry in China's manufacturing industry from 2011 to 2020 were clustered using SPSS 19.0. They can be divided into four categories ranging from high to low. The mean values of eco-innovation performance of "computer, communication, and other electronic equipment manufacturing", "transportation equipment manufacturing", and "electrical machinery and equipment manufacturing" are 2.4996, 2.3080, and 2.0318,

respectively, ranking in the first tier; the values of “special equipment manufacturing” and “general equipment manufacturing” are 1.6390 and 1.6112, respectively, ranking the second tier. On the other hand, the average performance of 20 industries, including the “agriculture and food processing industry” and “food manufacturing industry”, varied between 1.0230 and 1.3604; the “ferrous metal smelting and rolling industry”, “paper and paper products industry”, and “non-metallic mineral products industry” have respective average values of 0.8808, 0.8878, and 0.91276.

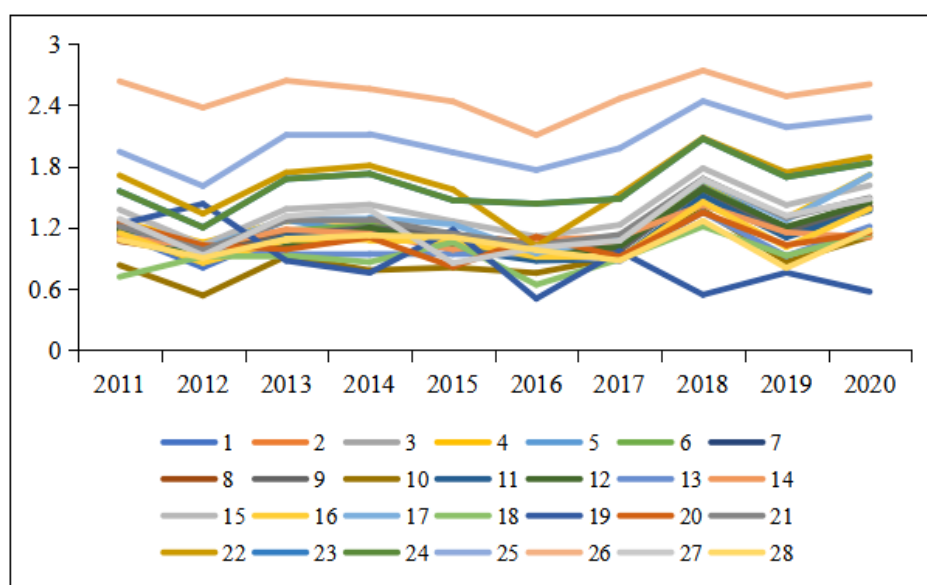


Figure 2. Best projection values of eco-innovation performance of China’s manufacturing industry by industry.

Explanatory variable (ERC_{it} , ERM_{it}): Numerous academics use single indicators to measure environmental regulation, such as energy consumption per unit of GDP [44], investment in environmental management [45], per capita income level [46], and the proportion of words appearing in government documents on environmental protection [47]. However, environmental regulation policies are multidimensional [48], and a single indicator cannot adequately measure the “strictness” of environmental regulation; consequently, many scholars have employed multiple secondary indicators to construct comprehensive indicators of environmental regulation. These secondary indicators include the compliance rate for “three wastes” [49], the number of administrative punishment cases at this level, the emission fees, and the number of closed petitions. Since environmental regulation is an organisational behaviour, in this paper, we select “the ratio of environmental protection investment amount/gross industrial output value of industries above the scale” of “three simultaneous” projects in industries above the scale as the implementation status of command-based environmental regulation tools and “the revenue from sewage charges in industries above the scale” as the implementation status of “three simultaneous” projects in industries above the scale. Therefore, the ratio of environmental protection investment amount to the gross industrial output value of industries above the scale is chosen in this paper to measure the implementation of market-based environmental regulation tools.

Control variable: Equivalent full-time R&D personnel is selected to measure HCI_{it} . The total output value of the industry above the scale or the number of enterprises above the scale is selected to represent HCI_{it} ; for EO_{it} , the ratio of foreign direct investment in fixed assets/the gross industrial output value of industry above the scale is selected for measurement in this paper. Since industry-specific data on foreign direct investment are unavailable, foreign investment in fixed assets is used as a proxy for foreign direct investment.

3.2. Data Sources

Due to data limitations, the sample evaluation period is 2011–2020, and the data on R&D personnel, internal expenditure of R&D funds, sales revenue of new products, the contribution rate of total assets, number of patent applications, the gross industrial output value (due to a change in the statistical calibre of the China Statistical Yearbook in 2012, there have been no data on gross industrial output value by industry in the Statistical Yearbook since 2012; hence, the data on industrial sales value are used instead), and industrial sales value were obtained from the China Science and Technology Statistical Yearbook (2011–2020). The data on industrial sales value and industrial pollutant emissions and energy consumption were obtained from the China Environmental Statistical Yearbook (2011–2020), the China Energy Statistical Yearbook (2011–2020), and the China Industrial Statistical Yearbook (2011–2020). The mean insertion method was used to fill in individually absent data.

4. Results

4.1. Panel Regression

In order to avoid the pseudo-regression caused by the non-stationarity of the data, in this paper, we employ ADF, LLC, IPS, and PP to conduct panel unit root tests. In conclusion, the results of the four tests are consistent, and the panel series of each variable in the model strongly rejects the original hypothesis, indicating that EIP_{it} , ERC_{it} , ERC_{it}^2 , ERM_{it} , ERM_{it}^2 , $InHCI_{it}$, ES_{it} , and EO_{it} are stationary and that the regression results are accurate. The final results of the regression analysis are displayed in Tables 3 and 4 below.

Table 3. Panel model estimation results of the effect of command-and-control environmental regulation on eco-innovation performance.

Explanatory Variable	Explanatory Variables: EIP_{it}		
	RE	FE	OLS
ERC	−107.2792 *** (−10.42)	−107.8958 *** (−10.45)	−104.9056 *** (−8.90)
ERC ²	3241.673 *** (4.20)	3244.047 *** (4.20)	3348.711 *** (3.75)
InHCI	0.2051 *** (18.62)	0.2068 *** (18.56)	0.1962 *** (16.58)
ES	0.0084 *** (5.34)	0.0084 *** (5.37)	0.0081 *** (4.46)
EO	11.5866 *** (4.83)	10.9037 *** (4.43)	15.6534 *** (−5.61)
Constant term	−0.7584 *** (−6.17)	−0.7674 *** (−6.73)	−0.7123 *** (−5.61)
Hausman test <i>p</i> -value	0.7551	−	−
Turning point	0.0165	0.0166	0.0157
N	280	280	280
R ²	0.6971	0.6972	0.6269

Note: *** indicate significance at the 1% levels.

Table 4. Panel model estimation results of the effect of market incentive-based environmental regulation on eco-innovation performance.

Explanatory Variable	Explanatory Variables: EIP_{it}		
	RE	FE	OLS
ERM	−781.9571 *** (−9.98)	−803.0877 *** (−10.14)	−657.0814 *** (−7.72)
ERM ²	147,078.7 *** (5.69)	150,536.4 *** (5.80)	129,426.1 *** (4.40)
InHCI	0.2025 *** (16.78)	0.2081 *** (16.83)	0.1883 *** (14.42)
ES	0.0083 *** (4.85)	0.0084 *** (4.88)	0.0080 *** (4.05)
EO	11.7822 *** (4.51)	10.7264 *** (4.01)	18.1369 *** (7.06)
Constant term	−0.7724 *** (−5.66)	−0.7847 *** (−6.291)	−0.7147 *** (−5.12)
Hausman test <i>p</i> -value	0.1516	−	−
Turning point	0.0027	0.0027	0.0025
N	280	280	280
R ²	0.6371	0.6374	0.5508

Note: *** indicate significance at the 1% levels.

Table 3 shows a positive coefficient of -107.279 for the ERC squared term and a negative coefficient of 3241.673 for the ERC, while Table 4 shows a positive coefficient of -781.9571 for the ERC squared term and a negative coefficient of $147,078.7$ for the ERC. The results indicate that both environmental regulations have a U-shaped relationship with firms' eco-innovation performance. The first hypothesis of this paper was tested. This differs from the results of Ramanathan et al. (2019) [50], who suggested that the relationship between environmental regulation and firm innovation performance is linear. The results presented in this paper show that the relationship is nonlinear and "U" shaped; before the inflection point, an increase in the intensity of environmental regulations inhibits the improvement of firms' eco-innovation performance. After the inflection point, increasing the intensity of environmental regulations improves the eco-innovation performance of firms. The regression results show that the inflection point is 0.0165 for the command type and 0.0027 for the market type and that the mean value of the intensity of environmental regulation in China is currently 0.0022 for the command type and 0.002 for the market type, with the former being to the left of the inflection point and the latter being very close to it. This suggests that the government must increase the intensity of command-based regulatory instruments in order for them to cross the inflection point and achieve better implementation results.

The coefficients for investment in human capital ($\ln HCI_{it}$), openness of the economy (EO_{it}), and firm size (ES_{it}) are 0.2051 , 0.0084 , and 11.5866 , respectively, in Table 3 and 0.2025 , 0.0083 , and 11.7822 , respectively, in Table 4, and all are significant at the 1% level. This suggests that all three indicators are positively related to firms' eco-innovation performance and that economic openness has the greatest effect of these three control variables. Thus, the Chinese government must continue to strengthen its communication and cooperation with the global economy.

Given the different levels of economic development in central, western, and eastern China, we tested for regional heterogeneity in the impact of environmental regulations on corporate eco-innovation by dividing the 30 provinces (cities) into two major economic regions (i.e., eastern and central) and conducting group regressions, the results of which are shown in Table 5.

Table 5. Regression results.

Region	Midwest (FE)	East(FEE)
ERC	124.20 * (1.58)	70.41 * (0.70)
ERC ²	-4000.00 ** (-2.05)	-2980.80 (-1.11)
ERM	1468.70 ** (1.99)	4163.40 ** (2.12)
ERM ²	$-238,890.30$ * (-1.71)	$-1,155,727.40$ (-1.49)
$\ln HCI$	3.19 *** (4.76)	5.64 *** (6.06)
EO	1.19 *** (4.76)	5.64 *** (6.06)
ES	2.14 *** (4.16)	5.64 *** (1.06)
-Cons	-24.17 *** (-2.50)	-64.02 (-4.87)
N	110	86

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 5 shows that the primary and secondary coefficients of the ERC are 124.20 and -4000 , respectively, in the central region, while the values are 70.41 and -2980.80 , respectively in the west, showing that the effect of the command-type environmental regulation instrument is more significant in the west. In contrast, the market-based effects are more significant in the east, where hypothesis 3 was tested. This type of phenomenon occurs

because the central region is dominated by secondary industries, whereas the western region is dominated by primary industries with a greater concentration of pollutants.

Therefore, the government must formulate appropriate, scientific, and reasonable environmental regulation policies according to the nature of industrial pollution in the region, the degree of industrial development, and the policy carrying capacity.

4.2. Threshold Model Test and Threshold Estimation

In this paper, we propose the use of the Yangtze River Economic Belt as a sample to study the performance of different environmental regulation tools in different regions [51]. The Yangtze River Economic Belt was chosen as the sample because it covers 11 provinces and cities, including Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Chongqing, Sichuan, Yunnan, and Guizhou, with a large geographical span. Moreover, these regions show obvious differences in the level of economic development, and such a selection allows for a more representative sample. In addition, in order to determine whether there is a threshold effect of environmental regulation on eco-innovation, a panel threshold model was developed as follows.

$$\ln EIP_{it} = \alpha + \beta_1 \ln ERC(ERM)_{i,t-1} G(X_{it} \leq \gamma_1) + \beta_2 \ln ERC(ERM)_{i,t-1} G(\gamma_1 \leq X_{it} \leq \gamma_2) + \dots + \beta_n \ln ERC(ERM)_{i,t-1} G(X_{it} > \gamma_n)$$

where EIP_{it} is eco-innovation performance; EMC_{it} and EMR_{it} are core explanatory variables; $\gamma_1, \gamma_2 \dots \dots \gamma_n$ are thresholds to be estimated; $G(\cdot)$ is the indicator function, which is 1 when the threshold variable reaches the desired condition and 0 otherwise; $\beta_1, \beta_2 \dots \dots \beta_n$ are the regression coefficients of each threshold interval; X_{it} is the threshold variable; Z_{it} is the control variable; i and t are city and year, respectively; and ε_{it} is the residual term.

The final threshold estimation results are displayed in Table 6. At the scale of the Yangtze River Delta city cluster and the Chengdu–Chongqing city cluster, there is no threshold effect of command type on eco-innovation. However, there is a threshold effect at the Yangtze River midstream cluster scale, with a threshold value of 3.4557, corresponding to an actual environmental regulation intensity of -13.32 . As for market type, there is a threshold effect between the Yangtze River midstream city cluster and the Yangtze River Delta city cluster and human capital ($\ln HCI_{it}$). There is a single threshold effect in the Yangtze River Delta and the middle reaches of the urban agglomerations.

Table 6. Threshold effect test and estimation results.

	Threshold Variables	ERC _{it}	ERM _{it}	lnHCI _{it}	EO _{it}	ES _{it}
Yangtze River Delta City Cluster	Single-threshold test	26.07 (0.1007)	11.31 (0.6433)	48.16 ** (0.0167)	23.81 ** (0.0362)	15.01 (0.2833)
	Double-threshold test	-	-	-2377.42 * (1457.59)	11.15 (0.3167)	-
	Threshold values (γ_1) (corresponding actual value)	-	-	10.7118 (45002)	9.2199 (10112)	-
	Single-threshold Inspection	27.13 ** (0.0103)	19.84 * (0.0833)	24.04 ** (0.0333)	19.31 (0.1200)	15.38 (0.1833)
Middle Reaches of Yangtze River City Cluster	Dual-threshold inspection	17.74 (0.1067)	19.49 * (0.0600)	11.78 (0.3133)	-	-
	Three-threshold tests	-	8.91 (0.17467)	-	-	-
	Threshold values (γ_1) (corresponding actual value)	3.4557 (-13.32)	6.2265 (506)	9.5122 (9435)	-	-
	Threshold values (γ_2) (corresponding actual value)	-	6.7093 (820)	-	-	-
	Single-threshold test	26.07 (0.1007)	11.31 (0.6433)	48.16 ** (0.0167)	23.81 ** (0.0362)	15.01 (0.2833)

Table 6. *Cont.*

	Threshold Variables	ERC _{it}	ERM _{it}	InHCI _{it}	EO _{it}	ES _{it}
Chengdu– Chongqing City Group	Single-threshold inspection	8.77 (0.3933)	11.68 (0.1900)	14.15 (0.1600)	11.83 (0.1833)	6.20 (0.6167)
	Dual-threshold inspection	-	-	-	-	-
	Threshold values (γ ₁) (corresponding actual value)	-	-	-	-	-

Note: (1) The data in the table are F-statistic values, and the corresponding *p*-values are presented in in parentheses; **, and * indicate significance at 5%, and 10% confidence levels, respectively. (2) The bootstrap sampling number is 300. (3) - indicates omission, no data

4.3. Mediation Effect

A test model for mediating effect was developed using Wen Zhonglin’s (2004) test method. Then, using the Chinese interprovincial industrial panel data, a regression model was developed following the steps of the mediating effect test. The following are the specific models and configurations:

Step 1: Conduct regression with environmental regulation and eco-innovation performance as explanatory variables and add control variables. If it is significant, the test of the mediating effect will continue.

Step 2: Regression with industrial agglomeration as the explanatory variable, environmental regulation intensity as the explanatory variable, and the addition of control variables.

Step 3: Regression with eco-innovation performance as the explanatory variable and industrial agglomeration as the explanatory variable, along with the addition of control variables.

Table 7 reaffirms that the intensity of environmental regulation has a driving effect on eco-innovation. Table 8 displays the regression results with EIP as the explanatory variable; environmental regulation intensity (ERC/ERM) as the explanatory variable; and human capital input (HCI), economic development level (RGDP), firm profitability (PRO), and firm size (SIZE) as the control variables.

Table 7. Regression results of environmental regulation on ecological performance.

	Threshold Variables	ERC _{it}	ERM _{it}	InHCI _{it}	EO _{it}	ES _{it}
Yangtze River Delta City Cluster	Single-threshold test	26.07 (0.1007)	11.31 (0.6433)	48.16 ** (0.0167)	23.81 ** (0.0362)	15.01 (0.2833)
	Double-threshold test	-	-	-2377.42 * (1457.59)	11.15 (0.3167)	-
	Threshold values (γ ₁) (corresponding actual value)	-	-	10.7118 (45,002)	9.2199 (10,112)	-
Middle Reaches of Yangtze River City Cluster	Single-threshold inspection	27.13 ** (0.0103)	19.84 * (0.0833)	24.04 ** (0.0333)	19.31 (0.1200)	15.38 (0.1833)
	Dual-threshold inspection	17.74 (0.1067)	19.49 * (0.0600)	11.78 (0.3133)	-	-
	Three-threshold tests	-	8.91 (0.17467)	-	-	-
	Threshold values (γ ₁) (corresponding actual value)	3.4557 (-13.32)	6.2265 (506)	9.5122 (9435)	-	-
	Threshold values (γ ₂) (corresponding actual value)	-	6.7093 (820)	-	-	-
Chengdu– Chongqing City Group	Single-threshold inspection	8.77 (0.3933)	11.68 (0.1900)	14.15 (0.1600)	11.83 (0.1833)	6.20 (0.6167)
	Dual-threshold inspection	-	-	-	-	-
	Threshold values (γ ₁) (corresponding actual value)	-	-	-	-	-

Note: (1) The data in the table are F-statistic values, and the corresponding *p*-values are presented in in parentheses; **, and * indicate significance at 5%, and 10% confidence levels, respectively. (2) The bootstrap sampling number is 300. (3) - indicates omission, no data.

Table 8. Regression results of the effect of environmental regulation on industrial agglomeration.

Variable	Coefficient	Prob.
C	0.224626	0.0005
LQ(−1)	0.713787	0.0000
ERC	0.026772	0.0093
ERM	0.561149	0.0367
TRAN	0.134464	0.0001
EO	0.012062	0.2103
PRO	−0.004193	0.6840
BA	0.087433	0.2681
R-squared	0.982243	
Adjusted R-squared	0.979411	
F-statistic	346.8382	
Prob (F-statistic)	0.000000	

Policy and institutional factors, factor factors, spatial factors, and foreign trade factors, among others, primarily influence industrial concentration. Additionally, industry profitability and enterprise entry barriers are crucial reference indicators that influence industrial concentration. On this basis, the level of industrial concentration (LQ) was selected as the explanatory variable, and the intensity of environmental regulation (ERC/ERM) was selected as the explanatory variable. Meanwhile, the state of transportation infrastructure construction (TRAN), the degree of economic openness (EO), industry profitability (PRO), and entry barriers (BA) were chosen as control variables. The lag term of the dependent variable was added to the regression. The results are displayed in Table 8 below. The coefficient for the explanatory variable environmental regulation intensity is positive, indicating that environmental regulation promotes industrial agglomeration. The intensification of environmental regulation policies has prompted some companies to relocate to regions where environmental regulation is lax in order to cut costs. At the same time, as environmental regulations become more stringent, some enterprises that want to reduce costs through technological innovation are attracted to industrial parks for their superior technological and human capital.

The regression results indicate that industrial agglomeration harms technological innovation, likely due to China's current high industrial agglomeration level. The sharing of resources among enterprises may lead to "cognitive distance lock", "free-riding", and the "lemon phenomenon", diminishing technological innovation to some degree. As a result, the interest in technological innovation has diminished.

The absolute values of the regression coefficients for industrial agglomeration in Table 9 are greater than those in Table 10, indicating that environmental regulation mitigates the negative effects of industrial agglomeration on eco-innovation. Finally, regressions were conducted with ecological innovation performance as the dependent variable and environmental regulation intensity and industrial agglomeration as the independent variables, the results of which are presented in Table 11. At the 5% significance level, the regression results indicate that environmental regulation intensity and industrial agglomeration level significantly affect technological innovation. Consequently, industrial agglomeration partially mediates the environmental regulation process influencing technological innovation.

While encouraging industrial agglomeration, the empirical results indicate that regions should not pursue the degree of industrial agglomeration with a broad brush. In industrial agglomeration areas, the protection of intellectual property rights should be strengthened to avoid "free-riding" and the "lemon phenomenon" to effectively increase enterprises' enthusiasm for technological innovation. This includes strengthening the management of patented technologies, improving the supporting system for intellectual property rights, and strengthening the environment for intellectual property rights protection.

Table 9. Regression results of the effect of industrial agglomeration on eco-innovation performance.

Variable	Coefficient	Prob.
C	−11.83417	0.0000
LQ	−0.558971	0.0215
HCI	1.117242	0.4781
EO	37.88712	0.0000
RGDP	1.498992	0.0367
PRO	−0.053620	0.4220
SIZE	0.429312	0.0002
R-squared		0.984579
Adjusted R-squared		0.982534
F-statistic		481.5717
Prob (F-statistic)		0.00000

Table 10. Regression results of the effect of environmental regulation and industrial agglomeration on eco-innovation performance.

Variable	Coefficient	Prob.
C	−12.16398	0.0000
ERM	0.130238	0.0203
LQ	−0.512816	0.0155
ERC	1.355343	0.4008
RD	36.45062	0.0000
RGDP	1.540402	0.0000
PRO	−0.061813	0.3627
SIZE	0.418076	0.0003
R-squared		0.984313
Adjusted R-squared		0.982165
F-statistic		468.3895
Prob (F-statistic)		0.000000

Table 11. Robustness test results.

	TOLS	TOLS	TOLS	TOLS	GMM	GMM
ERC _{it}	73.48 ** (38.81)					−253,277 (1.73)
ERC _{it} ²		−0.090 (0.057)			−2,377.42 *	(1457.59)
ERM _{it}			947.98 ** (273.53)			
ERM _{it} ²				−236,754.8 ***		−129,751.3 ***
LnHCI _{it}	36.31 *** (8.33)	37.6833 *** (8.55)	33.24 *** (8.98)	34.44 *** (8.87)	33.48 *** (7.92)	32.67 *** (8.25)
EO _{it}	0.0001 *** (0.0000)	0.0001 *** (0.0000)	0.0001 *** (0.0000)	0.0001 *** (0.0000)	0.0001 *** (0.0000)	0.0001 *** (0.0000)
ES _{it}	46.17 * (24.56)	0.66 ** (0.31)	0.59 * (0.32)	0.63 ** (0.31)	0.58 *** (0.28)	0.54 ** (0.29)
Indus	−15.11 *** (2.94)	−12.86 *** (2.42)	−12.02 *** (2.42)	−12.35 *** (2.39)	−9.65 *** (2.30)	−9.56 *** (2.25)
−Cons	2011.48 *** (1.08)	2017.07 *** (2.38)	2013.74 *** (2.17)	2014.62 *** (2.08)	2013.85 *** (1.90)	2013.91 *** (1.90)
N	270	270	270	270	270	270
R ²	0.25	0.24	0.22	0.22	0.22	0.18
F	15.32	13.85	15.53	14.53		
P	0.00	0.00	0.00	0.00	0.00	0.00
Wald test	No weak knowl- edge	No weak knowl- edge	No weak knowl- edge	No weak knowl- edge		

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.4. Robustness Test

In this paper, we used the two-stage least squares estimation (TSLS) method for correction, selecting the posterior period environmental regulation as the instrumental variable, and tested the validity of the instrumental variable using the lone identification and weak identification tests to examine the stability of the regression results. The results are presented in Table 11 alongside a GMM method robustness test. The empirical results indicate that the quadratic and primary coefficients are positive and negative, respectively, which contradicts the findings of Brandt et al. (2019) [52]; Lu and Tao (2020) [53].

5. Conclusions and Policy Suggestions

According to the bottleneck constraints of resources and environment in the manufacturing industry, China's manufacturing industry is faced with the objective requirement of eco-innovation as the driver to maintain both economic growth and environmental quality, thereby increasing the demand for the manufacturing industry's ability to implement eco-innovation. The relationship between environmental regulation and manufacturing eco-innovation performance was examined, and the hypotheses were theoretically analysed and empirically examined to determine their plausibility. After a summary of previous research, several policy implications are drawn.

5.1. Conclusions

Based on the input–output perspective, a manufacturing eco-innovation performance evaluation index system was developed. Furthermore, the accelerated genetic algorithm of the projection tracing model was utilised to evaluate the eco-innovation performance of 28 industries in China's manufacturing industry from 2011 to 2020. On this basis, the impact of environmental regulation on manufacturing eco-innovation performance was proposed, an econometric model was developed to test the impact of environmental regulation on China's manufacturing eco-innovation performance, and the following conclusions are drawn:

(1) From 2011 to 2020, the value of China's manufacturing industry's eco-innovation performance was not exceptionally high, but it does exceed 1, with a fluctuating upward trend.

(2) Directive and market-based environmental regulatory instruments have a 'U'-shaped relationship with the eco-innovation performance of Chinese manufacturing firms. Unfortunately, the intensity of directive environmental regulation in China is currently low and still on the left side of the inflection point. At the same time, the current level of market-based regulation does not exceed the inflection point and is still in the range of inhibiting eco-innovation performance enough to stimulate firms' interest in eco-innovation.

(3) Industrial agglomeration has a mediating effect and a partial mediating effect on the environmental regulation process affecting technological innovation, as determined by a mediating effects model.

5.2. Policy Suggestions

To improve the eco-innovation performance of Chinese manufacturing companies, we make the following recommendations.

First, the Chinese government should continue to improve environmental regulations and strictly enforce them so that green becomes the colour of "economic recovery" [54], that is, strengthen fines or increase incentives.

Secondly, scientific and reasonable environmental regulation policies should be formulated according to local conditions. Scientific and reasonable environmental regulatory policies are conducive to promoting technological innovation and economic expansion of enterprises [55]. In the central region, market-based environmental regulation is the main focus, and in the western region, command-based regulations should be the focus.

Thirdly, Chinese enterprises should increase their R&D expenditures. In the long run, firms should maximise the 'compensatory effect' of technological innovation [56].

Therefore, the government should provide greater loan subsidies to enterprises with high eco-innovation performance in order to support them in increasing their R&D expenditures.

Fourthly, the Chinese government needs to optimise the industrial layout and support mechanisms. The role of industrial agglomeration in technological innovation should be actively exploited [57,58].

5.3. Discussion

In this paper, we innovatively proposes a win–win evaluation index of corporate eco-innovation performance for both environment and economy. On this basis, we empirically tested the relationship between different types of environmental regulatory policies and corporate eco-innovation performance, as well as whether there is industry heterogeneity and geographical heterogeneity in different environmental regulatory instruments, as well as the mediating effect of the two.

However, the reality is that the various types of resources at the disposal of enterprises are limited. With current technological innovation having reached a certain level, how to use limited resources to improve the eco-innovation performance of enterprises is the focus of research, which was not examined in this paper; however, in the future, scholars can conduct research in this area. In other words, from the perspective of resource-based constraints, we explored the possibility of improving the level of enterprise eco-innovation by reconstructing the evaluation system of enterprise eco-innovation performance against the background of certain resource constraints and proposed corresponding management countermeasures for the improvement of enterprise eco-innovation performance.

Author Contributions: Data curation, J.W., S.H. and Z.Z.; methodology, J.W. and S.H.; writing—original draft preparation, J.W. and S.H.; writing—review and editing, J.W., S.H. and Z.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Shenzhen Philosophy and Social Science Planning Project (SZ2022D035) and the Guangdong Provincial Education Planning Project (2022GXJK587).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

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

References

1. Lee, J.; Veloso, F.M.; Hounshell, D.A.; Rubin, E.S. Forcing technological change: A case of automobile emissions control technology development in the US. *Technovation* **2010**, *30*, 249–264. [\[CrossRef\]](#)
2. Rubashkina, Y.; Galeotti, M.; Verdolini, E. Environmental regulation and competitiveness: empirical evidence on the Porter hypothesis from European manufacturing sectors. *Energy Policy* **2015**, *839*, 288–300. [\[CrossRef\]](#)
3. Fussler & James. *Environmental Regulation and Industrial Performance: Evidence from China*; Mimeo: New York, NY, USA, 1996.
4. Vollebergh, H. *Impacts of Environmental Policy Instruments on Technological Change*; OECD: Paris, France, 2007.
5. Bergquist, A.K.; Söderholm, K.; Kinneryd, H.; Lindmark, M.; Söderholm, P. Command-and-Control Revisited: Environmental Compliance and Technological Change in Swedish Industry 1970–1990. *Ecol. Econ.* **2013**, *85*, 6–19. [\[CrossRef\]](#)
6. Chang, C.H. The Influence of Corporate Environmental Ethics on Competitive Advantage: The Mediation Role of Green Innovation. *J. Bus. Ethics* **2011**, *104*, 361–370. [\[CrossRef\]](#)
7. Park, Y.S. A Study on the Determinants of Environmental Innovation in Korean Energy Intensive Industry. *Int. Rev. Public Adm.* **2005**, *9*, 89–101. [\[CrossRef\]](#)
8. Noail, Y.K.; Ryfisch, D. Multinational Firms and Internationalization of Green R & D: A Review of the Evidence and Policy Implications. *Energy Policy* **2015**, *83*, 218–228.
9. Zheng, D.; Shi, M. Multiple Environmental Policies and Pollution Haven Hypothesis: Evidence from China's polluting Industries. *J. Clean. Prod.* **2017**, *141*, 295–304. [\[CrossRef\]](#)
10. Wheeler, D. Racing to the bottom? Foreign investment and air pollution in developing countries. *J. Environ. Dev.* **2001**, *10*, 225–245. [\[CrossRef\]](#)
11. Wagner, M. On the relationship between environmental management, environmental innovation and patenting: Evidence from German manufacturing firms. *Res. Policy* **2007**, *10*, 1587–1602. [\[CrossRef\]](#)

12. Wurlod, J.D.; Noailly, J. The Impact of Green Innovation on Energy Intensity: An Empirical Analysis for 14 Industrial Sectors in OECD Countries. *Energy Econ.* **2018**, *71*, 47–61. [[CrossRef](#)]
13. Porter, M.E.; Linde, C.V.D. Toward a New Conception of the Environment-Competitiveness Relationship. *J. Econ. Perspect.* **1995**, *9*, 97–118. [[CrossRef](#)]
14. Bu, M.L.; Qiao, Z.Z.; Liu, B. Voluntary Environmental Regulation and Firm Innovation in China. *Econ. Model.* **2020**, *89*, 10–18. [[CrossRef](#)]
15. Zhuge, L.Q.; Richard, B.F.; Matthew, T.H. Regulation and Innovation: Examining Outcomes in Chinese Pollution Control Policy Areas. *Econ. Model.* **2019**, *89*, 19–31. [[CrossRef](#)]
16. Shi, X.; Xu, Z. Environmental Regulation and Firm Exports: Evidence from the Eleventh Five-Year Plan in China. *J. Environ. Econ. Manag.* **2018**, *89*, 187–200. [[CrossRef](#)]
17. Testa, F.; Iraldo, F.; Frey, M. The Effect of Environmental Regulation on Firms' Competitive Performance: The Case of the Building and Construction Sector in Some EU Regions. *J. Environ. Manag.* **2011**, *92*, 2136–2144. [[CrossRef](#)] [[PubMed](#)]
18. Steinhorst, J.; Matthies, E. Monetary or environmental appeals for saving electricity? Potentials for spillover on low carbon policy acceptability. *Energy Pol.* **2016**, *93*, 335–344. [[CrossRef](#)]
19. Stucki, T.; Woerter, M.; Arvanitis, S.; Peneder, M.; Rammer, C. How different policy instruments affect green product innovation: A differentiated perspective. *Energy Policy* **2018**, *114*, 245–261. [[CrossRef](#)]
20. Yuan, B.; Ren, S.; Chen, X. Can environmental regulation promote the coordinated development of economy and environment in China's manufacturing industry? a panel data analysis of 28 sub-sectors. *J. Clean. Prod.* **2022**, *149*, 11–21. [[CrossRef](#)]
21. Zaman, K.; Moemen, M.A. Energy Consumption, Carbon Dioxide Emissions and Economic Development: Evaluating Alternative and Plausible Environment Hypothesis for Sustainable Growth. *Renew. Sustain. Energy Rev.* **2022**, *41*, 237–247. [[CrossRef](#)]
22. Yuan, R.L.; Wen, W. Managerial Foreign Experience and Corporate Innovation. *J. Corp. Financ.* **2019**, *48*, 752–777. [[CrossRef](#)]
23. Yang, L.; Hamori, S. The role of the carbon market in relation to the cryptocurrency market: Only diversification or more? *Int. Rev. Financ. Anal.* **2023**, *77*, 101864. [[CrossRef](#)]
24. Ren, Y.Y.; Zhang, G.L. Can city innovation dispel haze? Evidence from the perspective of spatial spillover. *China Popul. Resour. Environ.* **2021**, *30*, 111–120.
25. Zhang, J.T.; Xu, Y.J. Environmental regulation, agricultural green TFP and grain security. *China Popul. Resour. Environ.* **2022**, *29*, 167–176.
26. Ma, J.; Wang, G.J. Impact of environmental regulation on the upgrading of industrial structure: Empirical analysis based on China's coastal city systematic GMM. *Sci. Technol. Manag. Res.* **2019**, *39*, 163–169.
27. Chen, Z.; Kahn, M.E.; Liu, Y.; Wang, Z. The consequences of spatially differentiated water pollution regulation in China. *J. Environ. Econ. Manag.* **2022**, *88*, 468–485. [[CrossRef](#)]
28. Brunel, C.; Levison, A. Measuring the stringency of environmental regulations. *Rev. Environ. Econ. Policy* **2023**, *10*, 47–67. [[CrossRef](#)]
29. Zhong, M.C.; Li, M.J.; Du, W.J. Can environmental regulation force industrial structure adjustment: An empirical analysis based on provincial panel data. *China Popul. Resour. Environ.* **2023**, *25*, 107–115.
30. Fu, J.Y.; Li, L.S.A. case study on the environmental regulation, the factor endowment and the international competitiveness in industries. *Manag. World* **2010**, *10*, 87–98.
31. Zhu, P.F.; Zhang, Z.Y.; Jiang, G.L. Empirical study of the relationship between FDI and environmental regulation: An intergovernmental competition perspective. *Econ. Res. J.* **2011**, *46*, 133–145.
32. Li, L.; Tao, F. Selection of optimal environmental regulation intensity for Chinese manufacturing industry: Based on the green TFP perspective. *China Ind. Econ.* **2012**, *5*, 70–82.
33. Porter, M.E. America's Green Strategy. *Sci. Ameracian* **1991**, *4*, 168–264. [[CrossRef](#)]
34. Chintrakarn, P. Environmental Regulation and U.S. State's Technical Inefficiency. *Econ. Lett.* **2018**, *100*, 363–365. [[CrossRef](#)]
35. Kemp, R.; Pontoglio, S. The Innovation Effects of Environmental Policy Instruments—a Typical Case of the Blind Men and the Elephant. *Ecol. Econ.* **2019**, *72*, 28–36. [[CrossRef](#)]
36. Gray, W.B. The Cost of Regulation: OSHA, EPA and the Productivity Slowdown. *Am. Econ. Rev.* **1987**, *77*, 998–1006.
37. Apay, E.; Buccola, S.; Kerkvliet, J. Productivity Growth and Environmental Regulation in Mexican and U.S. Food Manufacturing. *Am. J. Agric. Econ.* **2020**, *84*, 887–901.
38. Ramanathan, R.; He, Q.; Black, A.; Ghobadian, A.; Gallea, D. Environmental regulations, innovation and firm performance: A revisit of the Porter hypothesis. *J. Clean. Prod.* **2017**, *155*, 79–92. [[CrossRef](#)]
39. Ramanathan, R.; Black, A.; Nath, P.; Muyltermans, L. Impact of environmental regulations on innovation and performance in the UK industrial sector. *Management Decis.* **2019**, *28*, 299–312.
40. Yang, L.; Wang, L.; Ren, X. Assessing the impact of digital financial inclusion on PM2.5 concentration: Evidence from China. *Environ. Sci. Pollut. Res.* **2022**, *29*, 22547–22554. [[CrossRef](#)] [[PubMed](#)]
41. Brandt, L.; Biesebroeck, J.V.; Zhang, Y. Creative Accounting or Creative Destruction? Firm-Level Productivity Growth in Chinese Manufacturing. *J. Dev. Econ.* **2019**, *97*, 339–351. [[CrossRef](#)]
42. Lu, J.; Tao, Z. Trends and determinants of China's industrial agglomeration. *J. Urban Econ.* **2020**, *65*, 167–180. [[CrossRef](#)]
43. Yuan, B.; Xiang, Q. Environmental regulation, industrial innovation and green development of Chinese manufacturing: Based on an extended CDM model. *J. Clean. Prod.* **2018**, *176*, 895–908. [[CrossRef](#)]

44. Sun, L.Y.; Miao, C.L.; Yang, L. Ecological-economic efficiency evaluation of green technology innovation in strategic emerging industries based on entropy weighted TOPSIS method. *Ecol. Indic.* **2017**, *73*, 554–558. [[CrossRef](#)]
45. Yang, L. Idiosyncratic information spillover and connectedness network between the electricity and carbon markets in Europe. *J. Commod. Mark.* **2022**, *25*, 100185. [[CrossRef](#)]
46. Yang, L.; Xu, H. Climate value at risk and expected shortfall for Bitcoin market. *Clim. Risk Manag.* **2021**, *32*, 100310. [[CrossRef](#)]
47. Cai, X.; Hamori, S.; Yang, L.; Tian, S. Multi-Horizon dependence between crude oil and East Asian stock markets and implications in risk management. *Energies* **2020**, *13*, 294. [[CrossRef](#)]
48. Yang, L.; Yang, L.; Ho, K.C.; Hamori, S. Dependence structures and risk spillover in China's credit bond market: A copula and CoVaR approach. *J. Asian Econ.* **2020**, *68*, 101200. [[CrossRef](#)]
49. Xu, H. Regional R&D Investment and New Product Development Performance of Enterprises under the Background of Knowledge Activities. *Open J. Soc. Sci.* **2018**, *3*, 183–199.
50. Yang, L. Connectedness of economic policy uncertainty and oil price shocks in a time domain perspective. *Energy Econ.* **2019**, *80*, 219–233. [[CrossRef](#)]
51. Yang, L.; Yang, L.; Ho, K.C.; Hamori, S. Determinants of the long-term correlation between crude oil and stock markets. *Energies* **2019**, *12*, 4123. [[CrossRef](#)]
52. Meadows, D.; Randers, J. *The Limits to Growth*; Universe Books: New York, NY, USA, 1972.
53. Chassagnon, V.; Haned, N. The relevance of innovation leadership for environmental benefits: A firm-level empirical analysis on French firms. *Technol. Forecast. Soc. Change* **2015**, *91*, 194–207. [[CrossRef](#)]
54. Andersen, M.M. Eco-innovation-towards a taxonomy and a theory. In Proceedings of the 25th Celebration DRUID Conference, Copenhagen, Denmark, 17–20 June 2008.
55. Pereira, A.; Vence, X. Key Business Factors for Eco-innovation: An Overview of Recent Firm-level Empirical Studies. *Cuad. Gest.* **2012**, *12*, 73–103. [[CrossRef](#)]
56. Jaffe, A.B.; Newell, R.G.; Stavins, R.N. A tale of two market failures: Technology and environmental policy. *Gen. Inf.* **2021**, *54*, 164–174. [[CrossRef](#)]
57. Requate, T.; Unold, W. Environmental policy incentives to adopt advanced abatement technology. Will the true ranking please stand up? *Eur. Econ. Rev.* **2022**, *47*, 125–146. [[CrossRef](#)]
58. Coria, J.; Hennlock, M. Taxes, permits and costly policy response to technological change. *Environ. Econ. Policy Stud.* **2021**, *31*, 35–60. [[CrossRef](#)]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.