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Exploring the Role of Environmental Regulation and Technological Innovation in Financial Performance: Evidence from Chinese Heavy-Polluting Industry

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Abstract: Environmental regulation is an important guarantee to realize the balanced development of economy and environment, and is the policy guidance of the government to the resource utilization of companies. Environmental regulation will make companies increase costs, and also promote companies to explore technological innovation. How to reverse the negative cost effect of environmental regulation and improve financial performance is a problem that the government and companies need to think about together. Based on the data from 2015 to 2019 of China's heavy-polluting industry of listed companies, this paper analyzes the impact of environmental regulation on financial performance. The results show that: (1) environmental regulation inhibits firms' short-term and long-term financial performance. Environmental regulation has formed the negative effect of cost crowding out; (2) environmental regulation positively affects technological innovation. Environmental regulation can stimulate companies to actively explore technological reform to cope with the requirements and restrictions of environmental regulation policies; (3) technological innovation is not significantly negatively correlated with corporate financial performance. Technological innovation input cannot directly lead to the improvement of financial performance in the current period; and (4) technological innovation positively mediates the relationship between environmental regulation and financial performance. That verifies a weak "Porter Hypothesis". "Innovation compensation effect" exists, and technological innovation can partially offset "cost crowding out effect" and slow down the inhibition relationship of environmental regulation on financial performance, but the innovation effect does not offset the environmental cost. According to the research results, environmental regulation still has a negative effect on the financial performance of listed companies in China's heavy-polluting industries. The government should formulate strict and stringent environmental regulation policies, guide companies to rationally use resources and protect the environment. Instead of passively responding to policies, companies should actively seek new technologies and alternative sources of energy. Companies try to amplify the compensation effect of technological innovation, reduce the cost crowding out effect of environmental regulation, and improve their value.

Keywords: environmental protection; innovation compensation effect; cost crowding effect; heavy-polluting industry

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1. Introduction

China's economy is developing rapidly. Problems, such as over-exploitation of resources and worsening pollution, are also increasing [1]. The path of production and consumption based on the large-scale exploitation of natural resources is not sustainable. During the 14th Five Year Plan Period, China has entered a new stage of development. Chinese economy has begun to transform from the traditional economic development model to a high-quality development model. China has adjusted the industrial structure and energy structure, and taken a path of ecological priority, green and low-carbon development. In September 2020, China put forward the goal of "peak carbon" by 2030

and "carbon neutral" by 2060, actively promoting carbon peak and carbon neutral. "Peak carbon" and "carbon neutral" is the main path to solve environment problems and realize sustainable development [2].

Green development is inseparable from environmental regulation. It is a direct or indirect means of restricting and intervening enterprises' pollution behavior, with the government as the main body, to protect the environment and correct the negative impact of environmental pollution. Environmental regulation is decisions that affect production and consumption activities, technology choices, pollution abatement measures and waste disposal. It is a tool and an important driving force of ecological innovation [3,4]. With the power of the market, environmental goals can be achieved through economic incentives [5].

China's environmental regulation has undergone the evolution from "pollution prevention and control" to "ecological priority" under "ecological civilization", which is synchronized with the development of China's industrial economy and environmental pollution (Table 1). In 1973, China held the first national conference on environmental protection. In 1983, China formally established three environmental protection policies, namely, "prevention first and prevention combined", "whoever pollutes who takes care of it", and "strengthening environmental management". In 1989, China implemented the target responsibility system for environmental protection, centralized pollution control. Sewage charges were added in 1990. In 1996, the environmental protection idea of "paying equal attention to pollution prevention and ecological protection" was proposed. China's environmental regulation policy system developed rapidly, and the policy changed from the emphasis on environmental protection to coordinated development. Since 2012, giving priority to ecological development has been put forward. On 1 January 2015, the Environmental Protection Law came into effect. The law strengthens the responsibility of the government and enterprises for environmental governance, while increasing the penalties for environmental pollution. The Environmental Protection Tax Law of China was officially implemented from 2018. It is China's first independent environmental tax with an explicit goal of environmental protection. Since then, environmental protection taxes have been levied instead of sewage charges [6–8].

As the subject of economic development, companies are profit-oriented micro-individuals, which will face the trade-off between environmental costs and corporate performance. Environment regulations bring extra costs that cause the declining competitiveness of companies [9]. At the same time, environmental regulations will make firms reform technological innovations by some stringent environment control criteria. That leads to a "win-win" for society and enterprises [10]. Technological innovation can effectively link the contradiction between environmental protection and economic [11]. In China, companies in heavy-polluting industries are mainly concentrated in manufacturing, which is an important pillar of economic development. According to data from the 2019 National Statistical Yearbook, the added value of manufacturing, electronics and heat and gas supply industries accounted for nearly 30 percent of GDP. For enterprises in heavy-polluting industries, under the national strategic background of ecological civilization construction, how to balance environmental regulation and enterprise development is an issue that needs to be weighed. This paper verifies the extent to which environmental regulation affects heavy-polluting industries in China.

This paper extends the existing literature in two aspects. First, based on the micro perspective, this study focuses on the mediating effect of technological innovation between environmental regulation and financial performance, and verifies the existence of the weak "Porter hypothesis" at the firm level. Secondly, this study helps companies to understand the short-term negative effects of environmental regulation and technological innovation and avoid the short-sighted behavior of enterprises passively responding to environmental regulation policies. It is true that environmental regulation will bring additional costs to enterprises. However, under the background of the world economy in green ecological development mode, companies can establish long-term competitive advantages by actively using technological innovation.

Table 1. Development schedule of environmental regulations and heavy industry.

Year	Development of Environmental Regulations	Development of Heavy Industry and Pollution
1973	Adopted the first environmental standards: Industrial waste discharge standards.	Heavy industry as the priority of development; Environmental pollution and ecological destruction.
1979	Issued the first Environmental Protection Law.	Heavy industry developed rapidly; Pollution was worsened.
1983	Prevention first and prevention combined; Whoever pollutes who takes care of it; Strengthening environmental management.	Light industry and heavy industry maintained balanced development; Worsening environmental pollution.
1989	Revised Environmental Protection Law; Implement the target responsibility system for environmental protection; Centralized pollution control; Permit system of sewage charges.	Light industry and heavy industry maintained balanced development; Output of heavy industry is slightly higher than that of light industry.
1996	Implement the Standards for Ambient Air Quality; Implement Comprehensive Emission Standards for Air Pollutants.	Rapid development of heavy industry; Increasing in urban pollution and air pollution.
2002	Implement Clean Production Promoting Law; Control pollution from source.	Rapid development of heavy industry; Greatly wasted energy and resource and pollution.
2012	Adhere to the environmental protection policy of giving priority to conservation, protection and natural restoration.	Proportion of heavy industry optimization callback; Development of heavily polluting industries is restricted by the elimination of backward production capacity and strict control of excess production capacity.
2015	Implement Revised Environmental Protection Law.	Excessive production capacity in traditional heavy-polluting industries.
2018	Implement Environmental Protection Tax Law; Ecological conservation has become a national strategy.	Industry structure upgrade and optimization; Significant pollution reduction in heavy-polluting industries.

Source: According to References [6,7].

2. Review of the Literature

2.1. Environmental Regulation and Financial Performance

2.1.1. Environmental Regulation Can Restrain Financial Performance

Environmental regulation will raise the cost of companies and form a cost crowding out effect. Walter (1979) proposed the "Pollution Haven Hypothesis", which proposes that if the developed countries implement strict environmental regulations, costs will increase and financial performance will be suppressed. In order to maximize profits, enterprises will reorganize their production decisions and transfer from developed countries to developing countries [9]. Many experts have verified that environmental regulation triggered a "crowding-out effect" to the competitiveness of manufacturing firms [12,13] and strict environmental regulation will lead to the deterioration of the financial condition of regulated enterprises [14]. The goal of a social governance environment and the profit goal of enterprises are in a state of "zero-sum game", which restrict each other. Enterprises will weigh the advantages and disadvantages in the dilemma of strengthening green environmental protection and pursuing high profits. As the government strengthens environmental regulations, enterprises will have to pay more environmental taxes or sewage charges, which will raise production costs. This leads companies not only to lose productivity, but also to reduce output and raise prices, leading to lower profit margins. This is why environmental regulations have a negative impact on corporate financial performance [15]. An environmental investment constraint mandates for regulations that are productive in an environmental governance approach, but have no value for productivity in the traditional economic sense [16]. Stringent environmental policy regimes may limit a company's financial opportunities, because companies have to spend millions of dollars a year for environmental pollution controls technology and applying for environmental permits. These expenses will result in lower financial performance [17].

2.1.2. Environmental Regulation Can Promote Financial Performance

Porter put forward the "Porter Hypothesis", and many experts have carried out tests on the Porter hypothesis. Porter (1995) believes environmental regulations bring direct costs to some companies; at the same time, they will stimulate enterprises to increase investment in environmental protection, continue to innovate, give full play to "innovation advantages", partly or completely offset the costs of regulations, and bring competitive advantages to enterprises [10]. When the intensity of environmental regulation is greater, the enterprise's investment in environmental protection will be greater, which will improve the productivity of the enterprise [18]. Environmental investment will bring greener product to meet the market's "green procurement". Environmental regulations are positively associated with corporate economic performance [19,20]. There is the lag effect of environmental regulation on a firm's value [21]. Some scholars believe that whether environmental regulation can promote enterprise competitiveness is conditionally limited. When environmental regulation can meet the cost of potential innovation projects, they are effective in promoting productivity [22]. Those companies that are dynamic, willing to innovate and actively respond to environmental regulations are more willing to use a positive way of environmental management and better sustainable development [23].

2.1.3. The Impact of Environmental Regulation on Financial Performance Is Uncertain

The "Uncertainty hypothesis" argues the influences of environmental regulation on productivity are uncertain because factors influencing their relationship are uncertain [24]. Different policies and objectives of environmental regulations have different effects on the financial performance of enterprises [25]. Environmental regulation cannot affect business performance through environmental commitment and sustainability exploration innovation [26]. Borsatto et al. (2021) performed a systematic review on studies on environmental regulations, innovation and performance, and found that there are still inconsistencies of the relationship in the literature [27]. Zhang et al. (2022) investigated the relationship between environmental regulations and enterprise innovation performance and found the two had a U-shaped relationship, where R&D investments play an intermediary role [28].

2.2. Environmental Regulation and Technological Innovation

Environment regulation should take into account current technology [29]. Environmental regulation can positively influence technological innovation [30], increase technological innovation investment [31] and encourage green technology innovations effectively [32]. The lagged environmental compliance expenditures have a significant positive effect on research and design expenditures [11]. Environmental regulation has externality to technological innovation, and has an inverted U-shaped relationship with R&D. Appropriate regulation can promote the development of technological innovation [33]. Technological innovation is influenced by many other factors, such as policy uncertainty and political connections [8,34].

2.3. Environmental Regulation, Technological Innovation and Financial Performance

Environmental regulation will encourage enterprises to improve resource utilization. Reasonable regulations will bring an "innovation compensation effect". It can accelerate green innovation behavior. However, according to Porter's hypothesis, in the long run, environmental regulation will promote companies' technological innovation, forcing companies to invest in R&D, so as to obtain innovation compensation, and improve enterprises' competitiveness [10]. The role of environmental regulation on the enterprises' performance depends on which is stronger, the innovation compensation effect or the cost compliance effect [11]. Some scholars believe that environmental regulation will increase the "compliance cost", and will also stimulate innovative compensation effects, which are greater [35]. Some scholars found that, on the other hand, environmental regulation will induce innovation in clean technologies, but the costs outweigh the benefits [36].

Stricter regulation may increase R&D. If the new technology is relatively efficient in production, the Porter hypothesis ran [37]. Environmental regulation has a relatively obvious promoting effect on R&D investment of enterprises. Under these policies, enterprises must pay more environmental investment. Investment in environmental protection may crowd out the normal investment in production and operation of enterprises and reduce their financial performance [38]. Whether the Porter hypothesis is valid or not and whether environmental regulation raises innovation depends on the firm's characteristics, the means of environmental regulation and strategic behavior in the ecosystem [39].

2.4. Commentary on the Literature

Many scholars have done a lot of research on environmental regulation on financial performance. The existing literature still deserves further study. First, China's heavy-polluting industries are facing the pressure of transformation, and there are few studies that take heavy-polluting industries as research samples. Second, this paper wants to test the existence and strength of the Porter hypothesis in China's heavy-polluting industries. The Porter hypothesis states that technological innovation partially or fully compensates for the cost effect. The heavy-polluting industry is the key object of environmental regulation. Can technological innovation compensate for the negative effect of environmental regulation? Data extrapolation conclusions are needed to provide theoretical guidance for the development of heavy-polluting industries.

3. Hypothesis Development

3.1. Environmental Regulation and Financial Performance

The essence of environmental regulation economics is to internalize the negative externality of environmental pollution into the cost of enterprises. There is a contradiction between the environmental goal and the enterprise benefit maximization goal. Environmental regulation has the "cost crowding out effect". If the enterprise resources and technical factors of production have not changed, environmental regulation will lead to heavy-polluting enterprises increasing the environmental pollution treatment, such as the purchase of sewage treatment equipment, the corresponding human input, increasing pollution taxes, as breaking the original balance has reached the optimal configuration of production. The cost expenditure generated by environmental regulation can occupy other cost expenditure, forming a seesaw effect and causing the decline of short-term financial performance of enterprises.

As the Porter's hypothesis says, the application of environmental regulation to technological innovation is a process of first inhibition and then enhancement. The short-term "cost crowding out effect" of environmental regulation will gradually weaken as time goes by. Environmental regulation can prompt companies to do more environmental protection, increase investment in environmental protection, and promote technological innovation and green source investment. The positive effects will gradually offset the negative effects [21]. Under China's increasingly stringent environmental regulations, large companies have stronger bargaining power and face lower unit compliance costs [40]. Based on this, the following assumptions are made.

Hypothesis 1a (H1a). *Environmental regulation is significantly negatively correlated with short-term financial performance.*

Hypothesis 1b (H1b). *Environmental regulation is significantly positively correlated with long-term financial performance.*

3.2. Environmental Regulation and Technological Innovation

Under the strict environmental regulation policy, firms will not only increase pollution control, energy conservation and emission reduction, but also play the "first-mover advantage", adapt to the environment in advance, and put forward technological innova-

tion. The companies actively accelerate product transformation and upgrading by means of technological research and development, and promote clean production and resource recycling. Firms can adopt comprehensive utilization technology to reduce the generation of pollutants, increase green products, and fundamentally reduce the investment in pollution control and the use cost of environmental resources, so as to be less affected by environmental regulations in the future.

In the early stage of implementation, environmental regulation will lead to cost increase and output decrease, but in the later stage, it will improve production efficiency and reduce pollution; thus, stimulating technological innovation [41]. Hicks' innovation-inducing theory argues that strict regulation will lead to increased environmental costs. Tighter regulations will stimulate green technology innovations [32]. Based on this, the following assumption is made.

Hypothesis 2 (H2). *Environmental regulation positively affects technological innovation.*

3.3. Technological Innovation and Financial Performance

Technological innovation activities of enterprises can improve the production process, production technology or product innovation, and improve the production efficiency of enterprises. Technological innovation can reduce production cost and form product cost advantage or product differentiation advantage. New products can expand the market share of enterprises, enhance the market competitiveness, and improve financial performance [38]. R&D expenditure is a positive association with firm performance and value [42]. Based on this, the following assumption is made.

Hypothesis 3 (H3). *Technological innovation positively affects financial performance.*

3.4. Environmental Regulation, Technological Innovation and Financial Performance

Environmental regulation will increase the short-term cost pressure of enterprises, and will bring impetus to innovation. Environmental regulations force companies to raise awareness of environmental protection, increase investment in R&D, and increase technological improvement. Through the "innovation compensation effect" of technological innovation, the added value of products can exceed the cost increase caused by environmental regulations. Therefore, environmental regulation can increase the financial performance of enterprises through technological innovation. Direct environmental investment has a short-term effect, while technological innovation inspired by environmental investment has a long-term incentive effect [43]. Innovation plays a mediating role between the regulation and performance, perhaps because of the type of regulation, technological factors, market environment and firm structure [22]. Under environmental regulations, enterprises need to pay pollution charges, so they actively seek technologies with higher productivity and lower pollution, realize the innovation compensation effect, and improve the financial performance [44]. Based on this, the following assumption is made.

Hypothesis 4 (H4). *Technological innovation positively mediates the relationship between financial performance and environmental regulation.*

4. Variables and Models

4.1. Variable Definitions

4.1.1. Dependent Variables

Z-score is selected for the firm's short-term financial performance [45]. Edward Altman (1968) established a Z-score model. Z-score is a multivariate financial formula used to represent companies' financial health [46]. The formula for calculating the Z-score of a listed company is: Z-score = $1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5$. In the formula, X_1 = (working capital)/(total assets); X_2 = (retained earnings)/(total assets); X_3 = (earnings before interest and taxes)/(total assets); X_4 = (equity market value)/(total liabilities book

value); X_5 = (sales)/(total assets). Z-score is often used for financial early warning. When $Z < 1.81$, the company is in the bankruptcy zone; when $1.81 \leq Z < 2.67$, it is a gray zone; when $Z > 2.67$, it is a safe zone. When the Z-score value is smaller, the possibility of failure of the enterprise will be greater. If $Z < 1.81$, that means the company's financial situation is unstable.

TobinQ is selected for the long-term financial performance [47]. It can measure the investment value of company and the market evaluation of the company's growth by investors. When TobinQ value is higher, the company's development prospects and belief will be more optimistic, and the company will grow rapidly.

$$\text{TobinQ} = (\text{Total Market value})/(\text{Total Assets})$$

4.1.2. Independent Variables

At present, environmental regulation is mainly studied from macro and micro perspectives. From a macro perspective, it focuses on the impact of environmental regulation policies on regional economies or industries. Cao et al. (2017) used environmental pollution abatement costs to represent environmental regulations [48]. Cansino et al. (2021) used survey data retrieved from WEF to represent environmental regulations [49]. Li et al. (2022) used the frequency of the words related to environmental protection to measure the intensity of environment regulations [33].

The micro perspective focuses on the impact of environmental regulation. Enterprise pollutant discharge, sewage charges, environmental cost expenditure and environmental protection investment are widely used. The higher the cost of environmental protection fees paid by enterprises to meet environmental regulation policies, the greater the environmental protection supervision they receive. Wang et al. (2018) used the qualitative fuzzy indicator as environmental regulation. It was defined according to stakeholder's satisfaction with the effect of implementation of environmental regulation policies [50]. Investment expenditure on pollution control, penalty category and the number of fines of enterprise violations, frequency of environmental protection words in government reports and ISO 14000 certification are all used to measure environmental regulations [30,32,33,41,51].

This paper is based on a micro perspective. If the overall regional environmental regulation intensity is used, it is impossible to distinguish the differences of each individual company. Environmental protection investment is selected as a measure of environmental regulation [38,52,53]. Environmental protection investment includes environmental protection expenses and the purchase of environmental protection equipment [54]. Environmental protection investment is a voluntary environmental protection behavior adopted by enterprises in the context of environmental regulation, and is a reflection of environmental regulation policies in enterprises. Environmental protection investment can reflect the environmental technological transformation carried out by enterprises under environmental regulation, and is related to technological innovation. In this paper, "(environmental protection investment)/(operating income)" (ER1) is used to represent the intensity of environmental regulation.

Sewage charges are used to represent market-based regulations [52]. For testing a model's robustness, the indicator log of sewage charges (ER2) is also selected as an independent variable. Companies and institutions that discharge pollutants shall pay sewage charges. Sewage charges paid by each enterprise can reflect the degree of differential impact of environmental regulations on enterprises from a micro perspective. To avoid the impact of a company's size, it is expressed as a log of sewage charges. Environmental protection tax was levied in 2018. The taxable objects and collection standards of environmental protection tax are consistent with sewage charges. The "sewage charges" have been changed into "environmental protection tax" and policy consistency has been maintained. Therefore, before 2018, the data of "sewage charges" were selected, and after 2018, the data of "environmental protection tax" were selected.

4.1.3. Intermediary Variable

Technological innovation can be measured from three aspects: the investment of scientific research funds, the achievements and the investment in R&D personnel. R&D personnel are the main body of innovation activities, and their number directly determines the technological innovation behavior and innovation results. This paper selects the proportion of R&D personnel (TI) to measure technological innovation.

4.1.4. Control Variables

A company's financial performance is affected by external and internal factors. External factors include the degree of economic development and environmental factors. Environmental regulation is an external factor that affects the financial performance of enterprises. This paper internalizes the external effect, and measures the impact of environmental regulation on individual micro enterprises by taking environmental protection investment and sewage charges of enterprises, instead of taking environmental regulation policies or clauses as indicators. Internal factors include enterprise development strategy, life cycle and management style etc. This paper designs control variables from five perspectives of company size, ownership structure, management efficiency, solvency and operating ability, all of which are internal indicators that affect corporate financial performance [47,55].

Company size: The size of the company's assets is different, and the advantages in actual business activities are different. The company is a large-scale enterprise with rich assets and resources, and the company's management system and internal governance structure are more perfect. Businesses are more economically powerful and willing to comply with environmental regulations. The larger the company's assets, the higher its financial performance will be. So, the company size is set as the control variable [45].

Ownership structure: The shareholding concentration reflects the control of the company's distribution and the interests and needs of major shareholders. When the indicator is larger, the more the managers concentrate on decision making, and the more the company is capable of concentrating resources on innovation investment, which affects the financial performance. The proportion of the top ten shareholders (Top10) is used to measure the ownership structure.

Management efficiency: The management expense ratio is an important factor affecting the profitability of an enterprise and reflects the efficiency of the operation and management of the enterprise. The management fee ratio (MFR) is the ratio of administrative expenses to the revenue of the business. If the management fee ratio is higher, more profits are consumed by the organizational and management expenses, and the management efficiency is lower, which will reduce the financial performance.

Solvency: The cash ratio (CR) is used to represent the solvency. The more cash, the more sufficient internal funds the company has. Enterprises have the ability to increase technological innovation and promote the financial situation.

Operating ability: Inventory turnover ratio (ITR) is a comprehensive indicator that measures the production, inventory management level, and sales recovery ability of an enterprise. The inventory turnover ratio reflects the operating capacity of the enterprise. A fast inventory turnover rate indicates that the company's products are marketable and its financial performance is better.

The classification, labels and definitions of variables are shown in Table 2.

Table 2. Definition of variables.

Variables		Label	Definition
Dependent variables	Short-term financial performance	Z-score	Z-score = $1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5$
	Long-term financial performance	TobinQ	(total market value)/(total assets)
Independent variables	Environmental regulation	ER1	(environmental protection investment)/(operating income)
		ER2	Ln(Sewage charges)
	Technological innovation	TI	(number of R&D personnel)/(total number of employees)
Control variables	Company size	Size	Ln(total assets)
	Ownership structure	Top10	(number of shares held by top ten shareholders)/(total number of shares)
	Management efficiency	MFR	(administrative expenses)/(operating income)
	Solvency	CR	(cash and cash equivalents ending balance)/(current liabilities)
	Operating ability	ITR	(operating cost)/(inventory ending balance)

4.2. Methods

The research object is 104 heavy-polluting listed companies from 2015 to 2019, which is panel data. There is no missing observation value, which is a balanced panel. In order to study balanced panel data, this paper adopts a time and entity fixed effects model. It is a method of controlling for omitted variables in panel data that vary with individuals and with time, and is suitable for situations where there are two or more observations for each individual.

The vector form between the dependent variable Y_{it} and the independent variable X_{it} in the time and entity fixed effects model is expressed as [56]:

$$Y_{it} = \beta X'_{it} + \lambda_t + \mu_i + \varepsilon_{it} (i = 1, \cdots, n; t = 1, \cdots, T) \quad (1)$$

Of which: β is the intercept term of individual heterogeneity, X_{it} can vary with individuals and time. λ_t represents the time effect that does not change by the individual, μ_i and ε_{it} are compound disturbance terms, and ε_{it} is the overall disturbance term of the model. μ_i is related to some independent variable.

4.3. Models Construction

To test the research hypothesis, Model 1, Model 2, Model 3 and Model 4 were constructed accordingly:

First, in order to test whether the influence of environmental regulation on financial performance is significant, Model 1 is established, where Z-score is a short-term financial performance variable and TobinQ is an indicator for measuring long-term financial performance, respectively, verifying H1a and H1b.

$$\text{Z-score(TobinQ)} = \alpha_0 + \alpha_1 ER1 + \alpha_2 Size + \alpha_3 Top10 + \alpha_4 MFR + \alpha_5 CR + \alpha_6 ITR + \varepsilon \quad (2)$$

Second, to test whether environmental regulation's impact on the technological innovation is significant, Model 2 is established.

$$TI = \beta_0 + \beta_1 ER1 + \beta_2 Size + \beta_3 Top10 + \beta_4 MFR + \beta_5 CR + \beta_6 ITR + \varepsilon \quad (3)$$

Third, to test whether the impact of technological innovation on the financial performance is significant, Model 3 is established.

$$\text{Z-score} = \gamma_0 + \gamma_1 TI + \gamma_2 Size + \gamma_3 Top10 + \gamma_4 MFR + \gamma_5 CR + \gamma_6 ITR + \varepsilon \quad (4)$$

Fourth, to test whether technological innovation has a mediating effect between environmental regulation and financial performance, Model 4 is established.

$$\text{Z-score} = \delta_0 + \delta_1 ER1 + \delta_2 TI + \delta_3 ER1{*}TI + \delta_4 Size + \delta_5 Top10 + \delta_6 MFR + \delta_7 CR + \delta_8 ITR + \varepsilon \quad (5)$$

In the above formulas, α_0, β_0, γ_0, δ_0 represent constants, and ε represents residuals.

4.4. Sample Selection and Data Sources

Heavy-polluting industries are the key taxable objects of environmental protection tax [28]. Thermal power generation, cement, chemical industry, building materials, pharmaceuticals, textiles, fermentation, brewing and tanning are all defined as heavy-polluting industries. This paper takes listed companies of heavy-polluting industries, which listed on the Shanghai Stock Exchange and the Shenzhen Stock Exchange in China as object, and selects the data from 2015 to 2019. The sample companies marked ST or * ST were removed, and samples with missing data are removed. After sorting, 104 heavy-polluting companies are finally obtained, and a total of 520 valid observations are obtained. The financial data comes from the CSMAR database and the company's annual report. Individual missing data are filled manually by taking the average value of the data from the previous two years. Environmental protection investment data are mainly collected manually from company annual reports and sustainability reports. In the robustness test, the sewage charges from 2015 to 2017 come from the administrative expenses in the company's annual report, and the environmental protection tax from 2018 to 2019 comes from business tax and additional tax. To avoid extreme data, the data are shortened by winsorizing 1% to 99%, and Excel 2017 and Stata 14 are used for data processing and regression analysis.

5. Research Process and Results

5.1. Descriptive Statistics

Descriptive statistics show the observed, mean, and standard deviation minimum and maximum values of a sample variable. As can be seen from Table 3, from 2015 to 2019, the average Z-score of samples of listed companies in heavy-polluting industries is 3.329, and $Z > 2.67$. The average value of the sample companies is in the safe zone. The minimum value is 0.0405, so they are already in the bankruptcy zone and their financial performance was poor. The maximum value is 18.57, and the financial performance is excellent. The average value of TobinQ is 1.676, more than 1, which shows that the market has good expectations for the sample listed companies and has development potential. The average value of ER1, expressed as the proportion of environmental protection investment, is 1.401, the minimum value is 0.0018, and the maximum value is 24.07, indicating that the ratio of environmental protection investment to operating income is very different, and listed companies have different environmental protection investment policies under environmental regulation. The average proportion of technicians is 8.677, the minimum value is 0.2, and the maximum value is 25.5. The proportion of technicians varies greatly, and the overall proportion is high, reaching 8.677%. The larger standard deviations of Size, Top10, MFR, CR, and ITR indicate that the samples have a wider distribution range and are more representative.

Table 3. Descriptive statistics.

Variables	N	Mean	sd	Min	Max
Z-score	520	3.329	3.253	0.041	18.570
TobinQ	520	1.676	0.936	0.846	5.769
ER1	520	1.401	3.198	0.002	24.070
ER2	520	15.240	1.677	11.010	18.420
TI	520	8.677	5.621	0.200	25.500
Size	520	22.910	1.288	20.370	26.240
Top10	520	55.870	13.420	29.680	92.100
MFR	520	0.069	0.043	0.008	0.227
CR	520	0.359	0.375	0.024	2.315
ITR	520	0.682	0.410	0.180	2.189
Number of company	104	104	104	104	104

5.2. Correlations

The specific results of the correlation are shown in Table 4. Values of correlation regression coefficients are all less than 0.8, and it is acceptable for the variables to be included in the regression model.

Table 4. Correlations test.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Z-score	1.000								
(2) ER1	−0.175 ***	1.000							
(3) TI	−0.074 *	0.009	1.000						
(4) ER1*TI	−0.080 *	0.183 ***	0.979 ***	1.000					
(5) Size	−0.252 ***	0.503 ***	−0.101 **	−0.013	1.000				
(6) Top10	−0.059	0.289 ***	0.048	0.105 **	0.254 ***	1.000			
(7) MFR	0.118 ***	−0.103 **	−0.028	−0.046	−0.383 ***	−0.449 ***	1.000		
(8) CR	0.765 ***	−0.150 ***	−0.039	−0.050	−0.231 ***	−0.087 **	0.011	1.000	
(9) ITR	−0.006	0.126 ***	0.133 ***	0.157 ***	0.043	0.047	−0.004	0.168 ***	1.000

Note: ***, ** and *, respectively, represent significant at the significance level of 1%, 5% and 10%.

ER1 and Z-score are significant at the 1% level, and correlation coefficient is negative, which preliminarily confirms H1a, indicating that environmental regulation inhibits short-term financial performance. ER1 is not significantly associated with TI, and H2 is rejected. TI significantly affects the Z-score at the 10% level, preliminarily verifying H3; that is, technological innovation has a certain role in promoting financial performance. ER1*TI and Z-score are significant at the 1% level, which also preliminarily validates H4.

Size, MFR and CR are all significant at the 1% level, and have a significant impact on Z-score, while ITR and Top10 are not strongly correlated.

5.3. Regression Results and Discussion

Through correlation analysis, the impact of environmental regulation on short-term financial performance of enterprises is significantly negatively correlated at the level of 1%, which is further verified by firm and year fixed effect model. The regression results of fixed effects are shown in Table 5.

In Model 1, ER1 and Z-score have a significant negative correlation at the 1% confidence level, which is consistent with the negative correlation coefficient in the correlation analysis. H1a is accepted. Judging from the sample data of heavy-polluting industries, environmental regulation significantly inhibits short-term financial performance and has a cost crowding out effect. Taking TobinQ to represent long-term financial performance, the hypothesis that ER1 is significantly negatively correlated with TobinQ at the 5% confidence level shows the opposite result, which does not support H1b. Environmental regulation has a significant inhibitory effect on both short-term and financial performance of enterprises. Environmental protection investment expenditure increases enterprise costs, squeezes enterprise resources, and is negatively correlated with financial performance. Compared with the conclusions of other scholars, environmental regulation does not promote long-term financial performance. The main reason is that the lagged items of several periods of financial performance are not used to represent long-term performance, while the TobinQ for the current period is used, and the representativeness of the selection of indicators needs to be further explored.

In Model 2, ER1 is positively correlated with TI at 5% confidence level. Environmental regulation costs promote technological innovation. Therefore, accepting H2. The scale of the enterprise has a great influence. The larger the scale of the enterprise, the more strength and capital to increase technological innovation.

Table 5. Fixed effects regression (with ER1).

Model Variables	Model 1		Model 2	Model 3	Model 4
	Z-Score	Tobin Q	TI	Z-Score	Z-Score
Constant	25.67 ***	6.458 **	−8.153 *	29.96 ***	25.46 ***
	(8.987)	(3.259)	(4.475)	(8.945)	(8.926)
ER1	−0.0769 ***	−0.0218 **	0.0300 **		−0.191 ***
	(0.0271)	(0.00984)	(0.0135)		(0.0515)
TI				−0.0235	−0.0348
				(0.0229)	(0.0230)
ER1*TI					0.0104 ***
					(0.00401)
Size	−1.095 ***	−0.236 *	0.416 **	−1.289 ***	−1.074 ***
	(0.384)	(0.139)	(0.191)	(0.381)	(0.381)
Top10	0.0188	0.00498	−0.00317	0.0227	0.0187
	(0.0149)	(0.00540)	(0.00741)	(0.0150)	(0.0148)
MFR	−3.270	2.019	6.883 ***	−4.931	−2.984
	(3.501)	(1.270)	(1.743)	(3.478)	(3.477)
CR	1.132 ***	0.115	−0.0191	1.219 ***	1.140 ***
	(0.251)	(0.0910)	(0.125)	(0.251)	(0.249)
ITR	2.641 ***	0.654 ***	−0.0812	2.756 ***	2.626 ***
	(0.513)	(0.186)	(0.256)	(0.516)	(0.510)
Firm FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
R-squared	0.235	0.282	0.111	0.222	0.250
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000
obs	520	520	520	520	520

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In Model 3, TI and Z-score does not pass the significance verification, and the correlation coefficient between them is −0.0235. In the short term, technological innovation does not promote short-term financial performance; that is, technological innovation will increase the investment of enterprises in the short term and reduce financial performance. Therefore, rejecting H3. Judging from the single-index regression results of environmental regulation and technological innovation, both environmental regulation and technological innovation have brought cost pressure to enterprises, and have a negative impact on short-term financial performance. However, the effects of environmental protection investment and technology investment are lagging behind.

In Model 4, the multiplication term of ER1 and TI is added. After adding the multiplication term, the influence coefficient of ER1 on Z-score becomes −0.191, which is negatively correlated with short-term financial performance, and TI has a negative correlation with Z-score; the correlation coefficient is −0.0348. ER1*TI is verified at 1% confidence level, and the correlation coefficient is positive. There is no offset for the negative impact of ER and TI on short-term financial performance. Size CR and ITR are also important influencing factors. The result indicates that technological innovation has played an intermediary role in environmental regulation and financial performance. Under the influence of innovation and environmental protection investment, the negative effect of environmental regulation on financial performance has been alleviated. Technological innovation will play a role in innovation compensation, which verifies the existence of a weak "Porter Hypothesis"; that is, technological innovation compensation can partially offset the cost of environmental regulation, but does not reverse the cost-crowding effect. Therefore, accepting H4. It verifies that there is a mediating effect of technological innovation, which will slow down the negative relationship between environmental regulation and financial performance. In the context of sustainable economic development, the impact of environmental regulation on heavy-polluting industries is aggravated, and the financial performance shows a negative effect. This is also the situation that companies are facing, and it is the development bottleneck that needs to be broken through.

5.4. Robustness Test

5.4.1. Replacing the Measure of Independent Variable

Robustness tests can further verify the reliability of the conclusions. Replacing the independent variable ER1 "(environmental protection investment)/(operating income)" with ER2 (ln(sewage charge)). The entity fixed effects regression results are shown in Table 6. It is found that most of the conclusions are still valid.

Table 6. Fixed effects regression (with ER2).

Model Variables	Model 1		Model 2	Model 3	Model 4
	Z-Score	Tobin Q	TI	Z-Score	Z-Score
Constant	37.38 ***	17.16 ***	−31.36 *	37.69 ***	39.60 ***
	(7.969)	(3.066)	(17.35)	(7.963)	(8.181)
ER2	0.152 *	0.0821 **	0.491 **		−0.0403
	(0.0916)	(0.0352)	(0.199)		(0.138)
TI				−0.0338	−0.297 *
				(0.0225)	(0.157)
ER2*TI					0.0176 *
					(0.0102)
Size	−1.724 ***	−0.771 ***	2.038 ***	−1.625 ***	−1.680 ***
	(0.332)	(0.128)	(0.724)	(0.335)	(0.335)
Top10	0.0247	0.00918	−0.00416	0.0240	0.0251 *
	(0.0150)	(0.00576)	(0.0326)	(0.0150)	(0.0149)
MFR	−5.184	1.825	2.645	−4.137	−5.843
	(3.545)	(1.364)	(7.720)	(3.488)	(3.560)
CR	1.189 ***	0.0956	0.0231	1.177 ***	1.146 ***
	(0.251)	(0.0967)	(0.547)	(0.251)	(0.252)
ITR	2.440 ***	0.358 *	1.280	2.473 ***	2.452 ***
	(0.497)	(0.191)	(1.082)	(0.498)	(0.496)
R-squared	0.203	0.158	0.039	0.202	0.212
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000
obs	520	520	520	520	520

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The degree of influence of ER2 on short-term and long-term financial performance has changed, and the regression results show a significant positive correlation at the 10% and 5% level. Comparing with ER1 as an independent variable, the regression coefficient is opposite, resulting in the rejection of H1a. Comparing the sewage charges with the environmental protection investment in Table 7, it is found that the average value of the sewage charges in the sample companies is CNY 12.93 million, and the sewage charge is the minimum resource consumption that represents the company's compliance with environmental regulations [25]. The environmental protection investment includes not only the cost of environmental protection, but also the investment cost of environmental protection equipment, with an average value of CNY 108.7 million. From the perspective of environmental protection investment, the amount of environmental regulation is far greater than the sewage charges. A large amount of environmental protection expenditure will have a greater cost crowding out effect, crowding out other investment and expenditure costs, squeezing profit space, and inhibiting short-term financial performance. In addition, the data of sewage charges have been changed from sewage charges to environmental protection tax since 2018. The policy of changing environmental protection fee to tax has an impact on corporate performance [1], and may also affect the results. Therefore, the selection of indicators from different angles has different effects on the conclusions, which also verifies that some scholars' research results on environmental regulation on corporate financial performance are positively correlated, some are negatively correlated, and some scholars believe that the two are uncertain. The relationship is relatively large with the data selection.

Table 7. Comparison of sewage charges and environmental protection investment.

Variables	(1)	(2)	(3)	(4)	(5)
	N	Mean	sd	Min	Max
sewage charges (CNY ten thousand)	520	1293	2021	6.062	9987
environmental protection investment (CNY ten thousand)	520	10,870	26,535	5.675	171,718

5.4.2. System GMM Test

The impact of environmental regulation and technological innovation on financial performance has a lag [21], and the sample data become dynamic panel data with a lag period of the explained variable. These regress further with the generalized method of moments (GMM).

Among the research objects, n = 104, n > t, which is short panel data, and there is a linear relationship between variables, which is suitable for system GMM. For dynamic panel-data estimation, two-step difference GMM is used. This method can effectively avoid endogeneity problems between variables and between variables and residuals. In the system GMM regression (Table 8), *p*-values of AR(2) are all greater than 0.1, indicating that the generalized moment estimation of the system is effective, and the Hansen J test shows that the null hypothesis is accepted ($p > 0.05$), indicating that the hypothesis of 'exogenous instrumental variables' cannot be rejected. According to the generalized moment regression results, hypotheses H1a, H2 and H4 are accepted, and H1b and H3 are rejected. This is consistent with the fixed effect regression results, which proves that the results are robust.

Table 8. Two-step difference GMM.

Model Variables	Model 1		Model 2	Model 3	Model 4
	Z-Score	Tobin Q	TI	Z-Score	Z-Score
Constant	12.351 ***	2.265 **	12.773 **	13.562 ***	12.237 ***
	(4.767)	(0.975)	(7.045)	(5.174)	(4.608)
L1	0.083	0.527 ***	0.644 ***	0.216	0.307 **
	(0.238)	(0.125)	(0.113)	(0.176)	(0.156)
ER1	−0.130 **	−0.025 *	0.102 **		−0.211 ***
	(0.063)	(0.013)	(0.045)		(0.082)
TI				−0.019	−0.024
				(0.019)	(0.017)
ER1*TI					0.010 ***
					(0.003)
Size	−1.853 **	−0.09 **	0.411	−0.573 ***	−0.522 ***
	(0.837)	(0.041)	(0.276)	(0.212)	(0.188)
Top10	0.091 **	0.004	−0.006	0.007	0.011
	(0.043)	(0.003)	(0.012)	(0.009)	(0.009)
MFR	0.719	2.576 *	−6.76	−0.900	−0.221
	(5.89)	(1.389)	(5.276)	(4.385)	(3.801)
CR	0.944 *	−0.250	0.239	2.782 ***	2.356 ***
	(.482)	(0.197)	(0.422)	(0.860)	(0.774)
ITR	1.704 **	0.233 **	0.690	1.113 ***	1.000 ***
	(0.683)	(0.095)	(0.876)	(0.399)	(0.341)
AR(2)	−0.83	0.65	1.38	−0.53	−1.02
(*p*-value)	(0.409)	(0.514)	(0.166)	(0.594)	(0.307)
Hansen	12.75	34.28	9.44	13.60	11.89
(*p*-value)	(0.121)	(0.069)	(0.307)	(0.093)	(0.156)
obs	416	416	416	416	416

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

6. Recommendations and Conclusions

6.1. Recommendations

Environmental regulation policy is a double-edged sword, and both the state and enterprises have to weigh its costs and benefits [22].

First, improve the Environmental Protection Law and the Environmental Protection Tax Law. Environmental regulation is a fundamental means of securing sustainable development [57]. Environmental regulation in China is mainly driven by environmental protection laws. The introduction of "environmental protection tax" has increased the pollution cost of enterprises, promoted energy conservation and emission reduction, and forced enterprises to discharge pollutants to meet the standards. Pollutant enterprises have transformed from passive governance to active governance, and stimulated the active transformation and upgrading of enterprises. Strict and appropriate environmental regulations will encourage companies to use resources more effective [10]. The Chinese government should establish strict and effective environmental regulation policies, create a favorable environment for the implementation of environmental protection tax policies, and strictly enforce environmental protection laws. Environmental regulation also has an incentive and signaling role, giving rewards to companies that comply with environmental regulations, and, at the same time, signaling requirements to polluting companies.

Second, the government should speed up the transformation of environmental regulation policies. Inflexible regulations are likely to encourage firms to pursue costly compliance, but flexible regulations provide firms with the opportunity to respond dynamically, and help them to improve environmental and financial performance [23]. Government environmental regulation policies should be more flexible and transform from market-based to voluntary policies. Institutions are a key factor in ensuring more effective environmental protection measures. Not only does the tax law compel firms to pay environmental protection tax, but it also supports the development of advanced manufacturing and strategic emerging industries with low energy consumption and high added value through policies. This guides companies to consciously assume social responsibilities through environmental regulation policies and follow up with the latest international and domestic technical requirements, which causes companies to increase investment in environmental protection, tap the potential of technological innovation, provide green products, and gather the effect of technological innovation.

Third, companies should actively reverse the negative cost crowding out effect caused by environmental regulations. According to the research results, environmental regulation has a negative effect on both short-term and long-term financial performance. The environmental protection tax, as the most direct expenditure, will increase taxes on companies. Investment in environmental protection also includes costs that cannot be ignored. Companies should actively explore product transformation within the scope of complying with the relevant provisions of the tax law. Energy-saving materials and resources should be adopted to reduce the discharge of pollutants directly into the environment, reduce the cost of sewage discharge, and reduce the cost occupation of environmental regulations.

Finally, companies should actively play the role of compensation effect of innovation and the role of market main body. Under environmental regulations, firms should change the environmental model of "stimulus-response", passively adapting to the requirements of environmental policies, into an active model of "exploration-development-compliance-innovation". Enterprises should not only weigh the cost-benefit principle, but also actively seek breakthroughs. While increasing the technological innovation on advanced energy-saving, companies can pay more attention to the transformation to large-scale, integrated and deep-level innovation. Companies should have a long-term vision for development. In the short term, investment in environmental protection and technology research and development will squeeze other investment costs, but in the long run, compliance with environmental regulations will enhance the company's green consumption image and brand recognition, creating a greater reputation and a good social image, with a long-term fission effect.

6.2. Conclusions and Prospect

Taking the data of heavily polluting industries in China as samples, this paper verifies that technological innovation can mitigate the negative effect of environmental regulation on financial performance. The innovation compensation effect does not compensate for the cost crowding out effect, and the impact of environmental regulation on short-term and long-term financial performance is negatively correlated.

Under the background of pollution control, the development of heavy-polluting industries has been more restricted. The problem of environmental regulation and resource constraint is becoming more and more prominent. Heavy-polluting industries must complete their transformation and upgrading under the new situation. Heavy polluting industries can improve product quality, increase resource reuse, and reduce pollutant emissions and carbon emission reduction through new resources, new technologies or new processes. It is the key approach to seek development. It is hoped that future research will further expand the research sample, lengthen the time axis, and put forward more specific suggestions to companies.

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