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Original Research

Industry and Regional Environmental Regulations: Policy Heterogeneity and Firm Performance

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Abstract

This paper explores how different types of environmental regulations affect firm performance. Inspired by the Porter hypothesis, we propose a theoretical framework for distinguishing the heterogeneity of different types of environmental regulations. By focusing on technology-intensive manufacturers, this study analyzes a sample of 333 firms between 2008 and 2015 with a total of 2664 panel sample data observations. We find that both industrial environmental regulations and regional environmental regulations significantly affect firm performance, but their effects on firm performance are different. Regional environmental regulations are negatively related to firm performance, which is inconsistent with Porter's hypothesis. However, industrial environmental regulations and firm performance present an inverted U-shaped relationship, which is consistent with Porter's hypothesis. Industrial environmental regulations positively contribute to the progress of a firm's technological innovation up to a certain point, making a positive contribution to the improvement of firm financial performance. Beyond that, the bounded rationality of a certain threshold will considerably increase the cost for the firm to meet industry supervision. This makes the innovation compensation effect brought about by industrial environmental regulations unable to offset the attendant costs, which will significantly negatively affect firm performance. In addition, industrial environmental regulations and regional environmental regulations significantly interact with each other. A high degree of industrial environmental regulation will make the negative impact of regional environmental regulation on firm performance steeper. Lastly, we find that the level of regional economic development significantly affects the inverted U-shaped relationship between industrial environmental regulations and firm performance: A high level of regional economic development will make the inverted U-shaped relationship between industrial environmental regulations and corporate performance steeper.

Keywords: firms' performance, industrial environmental regulation, regional environmental regulation, U-shaped, policy heterogeneity

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Introduction

Jaffe and Palmer [1] divided the Porter hypothesis into three versions: weak Porter hypothesis, narrow Porter hypothesis, and strong Porter hypothesis [2]. This paper focuses on the strong Porter hypothesis, discussing the impact of industrial environmental regulations and regional environmental regulations on firm performance. Environmental regulations generally refer to a series of rules and regulations formulated and implemented by the country to protect the environment. They are a set of policy tools designed by the government to encourage firms to reduce environmental pollution and correct their negative externalities by stimulating technological innovation [3, 4]. Recent research suggests that environmental regulations mainly have negative, positive, or uncertain effects on corporate performance. Filbeck and Gorman [5] posited that environmental regulations (1) will increase the cost of firms, (2) will cause a continual decrease in the output and profit levels, (3) will reduce the financial returns of firms, and (4) will result in a decline in the overall competitiveness. Moreover, as firms have to increase their investment in pollution control, their investment in other productive activities will shrink. Therefore, if firms have limited resources, their development will be largely restricted, which will negatively affect their financial performance. Zhao et al., [6] investigated and found that environmental regulations increase the compliance cost of enterprises, and participating in carbon emission reduction efforts will increase the cost of the company, which runs counter to the profits of enterprises, thus having a negative impact on the performance of firms. Jorgenson and Wilcoxen [7] by studying the environmental regulations in various industries in the United States from 1973 to 1985, found that in the chemical, petroleum, ferrous metal, pulp and paper industries, environmental regulations would negatively affect the performance of firms. However, Porter and Van der Linde [8] challenged their hypothesis and demonstrated that the implementation of a certain degree of appropriate environmental regulations will considerably enhance the technological innovation of firms, which will motivate firms to take a series of measures to reduce costs in order to increase their market competitiveness. This will not only significantly improve the production efficiency of the firm, but also optimize the firm's industrial structure to a large extent, thereby enhancing firm performance. However, the prerequisite for this situation is that the design of appropriate environmental regulatory tools and the dynamic analysis model that meet consumer needs, technology requirements, resource allocation, and other elements are variable [9]. Ramanathan et al., [10] noted that the impact of environmental regulations on corporate performance is uncertain, and the relationship between them cannot be effectively distinguished.

Existing studies have not unified the impact of environmental regulations on firm performance, nor have they distinguished between regional environmental regulations and industrial environmental regulations on the policy heterogeneity of firm performance. If environmental regulation were to have a positive effect on firm performance, it depends on whether the regulation is a "flexible regulation" (also known as "innovative" regulation and "smart" regulation), which is a key driver for all stakeholders to achieve positive results [11]. Obviously, different types and degrees of environmental regulations have different implications on a firm's financial performance. We believe that the impact of industrial environmental regulations on firm performance is neither negative nor positive; instead, it manifests as an inverted U-shaped relationship. Industrial environmental regulations will bring positive innovation compensation and negative costs of meeting regulations [12]. The impact on corporate performance depends on the comparison of these two effects, and a certain degree of industry environmental regulation will make the positive effect greater than the negative effect, thereby promoting the growth of firm performance, while the industry environmental regulation exceeding a certain level will greatly increase the cost of compliance with negative environmental regulations, thereby negatively affecting firm performance. However, the overall impact of regional environmental regulations on firm performance is always negative. Both high-level and low-level regional environmental regulations will negatively affect the financial performance of firms. Regional environmental regulations will lead to more government intervention and affect the efficiency of firm decision-making [13]. Moreover, regional environmental regulations are unstable and cannot effectively stimulate the improvement of firms' technological innovation level [14, 15]. In addition, an unstable institutional environment will also considerably inhibit the operating efficiency of firms [16], which will reduce firm performance.The theoretical contributions of this paper are as follows. (1) This paper distinguishes the impact of different types of environmental regulations on corporate performance and expands the scope of Porter hypothesis. We find that industrial environmental regulations are consistent with Porter's hypothesis, while regional environmental regulations are not. The industrial environmental regulations and regional environmental regulations have policy heterogeneity in their impact on firm performance. We find that an inverted U-shaped relationship exists between industrial environmental regulations and firm performance, while a negative correlation exists between industrial environmental regulations and firm performance. (2) Our results also indicate that the level of regional economic development moderates the inverted U-shaped relationship between industrial environmental regulations and firm performance, which enhances the influence of Porter's hypothesis. When a firm's located regional economic development is high, the inverted U-shaped relationship is steeper, whereas when a firm's located regional economic development

is low, the inverted U-shaped relationship is flatter. (3) Our results also show that regional environmental regulations and industrial environmental regulations significantly interact with each other to explain the firm performance, in such a way that, when industrial environmental regulation is high, the negative impact of regional environmental regulation on firm performance is steeper.

The remainder of this paper is organized as follows. Section 2 reviews the existing literature and proposes hypotheses. Section 3 describes our data, sample, measures, and empirical strategy, and we analyze the results. Section 4 discusses the findings and results of this paper. Section 5 looks at the managerial implications for the field, limitations of the study, and future directions.

Theory and Hypothesis

Environmental Regulation and Firm Performance

A number of studies have attempted to assess the effects of environmental regulation on firm performance, and the effect is contentious [10, 17]. The Porter hypothesis suggests that a proper environmental regulation can promote technological innovation of firms and thus improve firm performance. Dynamically, when the intensity of environmental regulation increases, firms can cope with the increased costs due to the improvement of environmental regulation standards through internal excavation and technological innovation, that is, through the "innovation compensation" mechanism to offset or even exceed the adverse effects on the financial performance of firms caused by the increase of environmental regulation intensity [8], thereby enhancing firms' competitiveness and performance. Conversely, the strengthening of environmental regulations will lead to the internalization of environmental issues, increased spending on environmental governance, and investment in green innovation, which, according to the cost hypothesis, will significantly crowd out other productive investments and increase operating costs [18], thereby reducing firm performance. At the same time, according to Porter hypothesis, environmental regulation can promote the firms' input of R&D, but, unfortunately, the benefits of investment of R&D are lagging behind, being unable to offset the costs of environmental regulation at present. In addition, number of researches show that R&D input may also have a negative impact on firm performance [19]. Darnall et al., [20] found that strict environmental regulations are negatively related to firm performance. They believe that if a firm is faced with more stringent environmental regulations, the greater the likelihood of paying the price caused by environmental accidents, and the more likely the environmental rating will go down, ultimately leading to an increase in the operating costs of firms and resulting in a downward trend in firm performance.

However, recent studies do not distinguish between the heterogeneity of industrial environmental regulation and regional environmental regulation. Industrial environmental regulation is enforced for industry-wide companies [21], which places the firms in the industry in a relatively fair institutional environment. While the regional environmental regulation is aimed at the local firms in the region, reflecting the importance that each region attaches to environmental protection, the environmental regulations in different regions are not uniform – some are strong, some are weak – and the enforcement of environmental regulations in different regions is also not similar. This will create inconsistency of the institutional environment faced by firms within and outside the region, leading to the occurrence of unfair phenomena. Therefore, industrial environmental regulation and enterprise environmental regulation will inevitably have a differential impact on firms. By studying the policy heterogeneity of industrial environmental regulation and regional environmental regulation and their differential influence on firm performance, we can formulate environmental regulation policies more reasonably and protect the public's interests in environmental resources as well as the firms' interests to the maximum extent.

Industrial Environmental Regulation and Firm Performance

The influence of industrial environmental regulation on the business operation of firms is different from that of regional environmental regulation [21, 22]. Industrial environmental regulation aims to limit the discharge of pollutants or manufacturing equipment according to industrial environmental standards, thus affecting production activities. Different from regional environmental regulation, the impact of industrial environmental regulation on firms is industry-wide, which will affect all regions of the country, making the scope of influence wider and the degree of influence deeper. The policy makers of industrial environmental regulation are generally national trade associations, the central government, and related institutions, and the decision-making has nationwide influence. According to Porter hypothesis [8] proper implementation of environmental regulations is the only way to improve firms' performance; therefore, it can be inferred that a certain degree of industrial environmental regulations can promote firm performance and enable firms to reasonably deal with industrial environmental regulations. At the same time, Berman et al., [23] also demonstrated that the total factor productivity of firms affected by industrial environmental regulations increased significantly in 1982-1992, whereas the productivity of firms not subject to industrial environmental regulations decreased during the same period, indicating that industrial environmental

regulations have a positive impact on firm performance. However, different levels of environmental regulations have different effects on firm performance. Some studies have shown that there may be a threshold that triggers the induced effect of industrial environmental regulation [24], which makes a certain degree of industrial environmental regulation contribute to the improvement of firm performance, while exceeding a certain limit will hinder the improvement of firm performance. A high degree of industrial environmental regulation will bring "expensive supervision", especially for highly polluting industries [11], such as chemical, petroleum, ferrous metal, and pulp and paper. Stricter industrial environmental regulations will benefit firms that adopt new technologies, which will be lower than the cost of environmental supervision. This limits the ability of firms to pursue profits, which will significantly negatively affect firm performance [7]. Moreover, a high degree of industrial environmental regulation will compel firms to invest too many resources on reducing pollution. From a commercial point of view, even if these excessive investments reduce environmental pollution, they are not conducive to improving the competitiveness of firms. For instance, the industry's highly environmentally qualified technical standards limit the choice of technology or input in the production process and increase transaction costs, which inevitably consume the limited resources of the enterprise and reduce its competitiveness. However, a low degree of industrial environmental regulation will stimulate the improvement of technological innovation [3]. This improvement will reflect in improvement of product quality and production efficiency; moreover, it will reduce the cost of firms by developing new products and new processes, thereby increasing their profits as well as enhancing their competitiveness and performance. In short, industrial environmental regulation will bring both positive effect (innovation compensation) and negative effect (consequent cost) [3, 24], and the impact on firm performance depends on the comparison of these two effects. The innovation compensation effect brought about by low-level industrial environmental regulations is higher than the negative follow-up cost, while the follow-up cost is greater than the innovation compensation effect by high-level industrial environmental regulations; therefore, industrial environmental regulation–firm performance relationship is represented by an inverted U-shaped curve. Based on the above theoretical analysis, this study puts forward the following assumptions:

Hypothesis 1 (H1). Industrial environmental regulations and firm performance show an inverted U-shaped relationship.

Regional Environmental Regulation and Firm Performance

The influence of regional environmental regulation on firm performance is different from that of industrial environmental regulation. Regional environmental regulation mainly reflects the local government's emphasis on environmental protection [14, 25]. Many studies have shown that the intensity of regional environmental regulation is positively correlated with the government's investment in environmental governance [14]. High-intensity regional environmental regulation will lead manufacturing industries, especially heavy polluting firms, to invest a lot of money to evade regional environmental regulation [11], resulting in a relatively reduced investment in business operations and a lack of significant returns on the amount of money invested in environmental protection, which reduces the utilization efficiency of limited capital of firms. From this viewpoint, regional environmental regulation will increase the pressure of firm environmental governance and hinder the improvement of firm performance. Simultaneously, because of the active participation of government in environmental protection, regional environmental regulation may raise the environmental standards of manufacturing firms to some extent [6], which will increase the investment of firms in environmental protection and reduce the performance of firms. In addition, increased governmental intervention may affect the efficiency of strategic decision-making, thus further reducing firm performance [13]. From this point of view, regional environmental regulation may have a negative impact on firm performance. Another evidence shows that the Chinese government's intervention in companies is primarily regarding market and functional regulation, with a greater impact on investment and trade [26], which will significantly affect the investment efficiency of firms and thus the performance of firms. Furthermore, the regional environmental regulation is unstable, which is easily influenced by policy changes, major events, and accidents [14]. For example, during the 2008 Beijing Olympic Games, Beijing's environmental supervision was obviously stronger than other periods. According to institutional theory, when a firm faces an unstable institutional environment, its operating efficiency may be restrained [16]. Therefore, regional environmental regulation has a negative impact on firm performance. Moreover, unlike industrial environmental regulation, the impact of regional environmental regulation is local-wide. Even if it is a reasonable institutional design, because the impact is local rather than global, it will have a negative spillover effect on the business of other regions of the firm, which makes the regional environmental regulation have a negative relationship with the overall performance of the firm. In conclusion, we suggest that the overall impact of regional environmental regulation on firm performance is negative. Accordingly, we hypothesize the following:

Hypothesis 2 (H2). Regional environmental regulations negatively affect firm performance.

Moderating Effect

Environmental regulation will have an impact on local economic efficiency and economic development [27, 28]. Due to promoting economic development, economically underdeveloped areas may restrict the local implementation of industrial environmental regulation. Moreover, in the regions with a relatively low degree of economic development, firms have a strong sense of local protection [29]. The local government will assist firms to deal with economic disputes and, at the same time, help firms to avoid the obstacles of industry regulation and resist the implementation of industrial environmental regulation, as the saying goes, "One with great power cannot defeat a local villain" [29]. Under the influence of this local protectionism, although it may help reduce the cost of compliance with environmental regulation, it may also inhibit the innovation performance of firms in this region. As a result, the positive innovation compensation effect of environmental regulation on firm performance will also be weakened, thus the inverted U-shaped relationship between industrial environmental regulation and firm performance will be flattened. However, the environmental regulation issued by the local government has a strong warning effect so that the impact of regional environmental regulation on firm performance is not limited by the degree of local economic development. Conversely, in regions with high economic development – due to the higher per capita income level in these areas – residents generally pay more attention to their future living environment, have higher demand for environmental quality, and are more willing to buy environment-friendly products, so local firms are faced with higher environmental protection responsibility pressure, urging them to implement the constraints of industrial environmental regulations perfectly [30]. Therefore, regions with high regional economic development level will positively affect the implementation effect of industrial environmental regulations, which in turn will enhance the compensation effect of industrial environmental regulations on positive innovation of firms. At the same time, in regions with high economic development, environmental protection awareness and legal awareness are very strong, which will weaken the adaptation cost and conversion cost of the implementation of industrial environmental regulation instead, thus weakening the negative follow-up cost of industrial environmental regulation on firm performance, thus making the curvilinear (inverted-U) relationship between industrial environmental regulation and firm performance steeper as a whole. Moreover, the regional local governments with high level of economic development have their own environmental regulations on the performance of firms, not limited by the level of regional economic development. Therefore, this paper holds that the lower level of economic development of the region will flatten the inverted U-shaped relationship between industrial environmental regulation and firm performance, the higher level of economic development of the region will steepen the curvilinear (inverted-U) relationship between industrial environmental regulation and firm performance, that is, the level of regional economic development positively moderates the relationship between industrial environmental regulation and firm performance. From these above arguments, we propose the following:

Hypothesis 3 (H3). With the improvement of the level of regional economic development, the shape of the inverted U-shaped relationship between industrial environmental regulations and firm performance becomes steeper.

Industrial environmental regulation and regional environmental regulation interact with each other and industrial environmental regulation will moderate the impact of regional environmental regulation on firm performance. This paper argues that the improvement of industrial environmental regulation will make the impact of regional environmental regulation on firm performance steeper. While regional environmental regulation can only affect the business and operation of a certain place where the firm is located, industrial environmental regulation affects the business and operation of the whole industry. Therefore, the influence of industrial environmental regulation on firms is more important than that of regional environmental regulation. The attention-based theory of the firm suggests that there is competition for managers' attention (managers are selective in choosing what to focus), mainly because of their limited ability (limited attention) to focus on all external triggers they are exposed to [31]. Therefore, the attention to each specific stimulus depends on the attractiveness and value of alternative options [32]. Under the constraint of limited time and energy of firm managers, they will devote more energy to more important things. While the influence of industrial environmental regulation is far-reaching, it is more attractive than regional environmental regulation in firm operation. It can be proved that when firms allocate their attention resources, they give priority to industrial environmental regulation, thus "crowding out" the attention and investment of regional environmental regulation and partially "replacing" the influence of regional environmental regulation on firm performance. From the above analysis, we see that a low degree of industrial environmental regulation is conducive to the improvement of firm performance, which will partially offset the negative effects of regional environmental regulation on firm performance. However, with the continuous improvement of industrial environmental regulations, the "expensive supervision" that it brings will be significantly enhanced [11]. The negative follow-up costs to regional performance will be increased. As a result, the pressure of firm environmental governance increased by regional environmental regulations will be superimposed, thus aggravating the hindering effect of regional environmental regulations

on firm performance and making the negative relationship between regional environmental regulations and firm performance steeper.

In addition, the low-level industrial environmental regulation is relatively stable, and firms have already practiced avoiding these regulations in the long-term operation [22]. When firms are able to adapt well to a low-level industrial environmental regulation, the environmental governance level of it may have already been improved to a certain extent. At this time, the cost of environmental governance will no longer be obvious, and the negative effect of regional environmental regulation is even weaker. However, with the strengthening of industrial environmental regulation, firms need to adapt to a higher degree of industrial environmental regulation. According to the attention-based theory of the firm, managers have a limited ability to pay attention to all the external incentives they are exposed to, so issues that are more crucial to firms will receive more attention. Thus the strengthening of industrial environmental regulation results in a greatly increasing transformation cost faced by firms, this will enhance the negative impact of regional environmental regulation on firm performance [6].

In conclusion, industrial environmental regulations have greater importance and influence on firms and will partially "replace" the influence of regional environmental regulation. As expected, the relationship between industrial environmental regulation and firm performance is an inverted U-shaped. A low degree of industrial environmental regulation will weaken the negative relationship between regional environmental regulation and firm performance, but a high degree of industrial environmental regulation will enhance the negative impact of regional environmental regulation on firm performance. Based on the above theoretical analysis, we put forward the following hypothesis:

Hypothesis 4 (H4). With the improvement of industrial environmental regulations, the negative relationship between regional environmental regulations and firm performance will become steeper.

Methodology

Sample

In order to verify the hypothesis that industrial environmental regulation and regional environmental regulation have different impacts on firms as well as to emphasize the effectiveness of environmental regulation and its impact on firm performance, we selected China's technology-intensive manufacturers as our sample, because this group is characterized by high resource consumption and high output, such as high-end equipment manufacturing and new material development. Then we built our sample following these three steps. First, we selected technology-intensive manufacturers as benchmark samples from the China Stock Market & Accounting Research (CSMAR) database, which records all financial data and firm information of all listed companies in China, involving financial, stock, initial public offering (IPO) events, and other business information. We collected the financial data and firm characteristic index information of our sample firms, such as return on capital, firm size, firm type, and industry code.

Second, we collected supplementary firm financial information from the WIND database and compared this information with the collected enterprise information. For industry regulation data, we used China Industrial Database, which contains detailed information of each industry, such as annual pollution control cost and industry output. We also obtained environmental

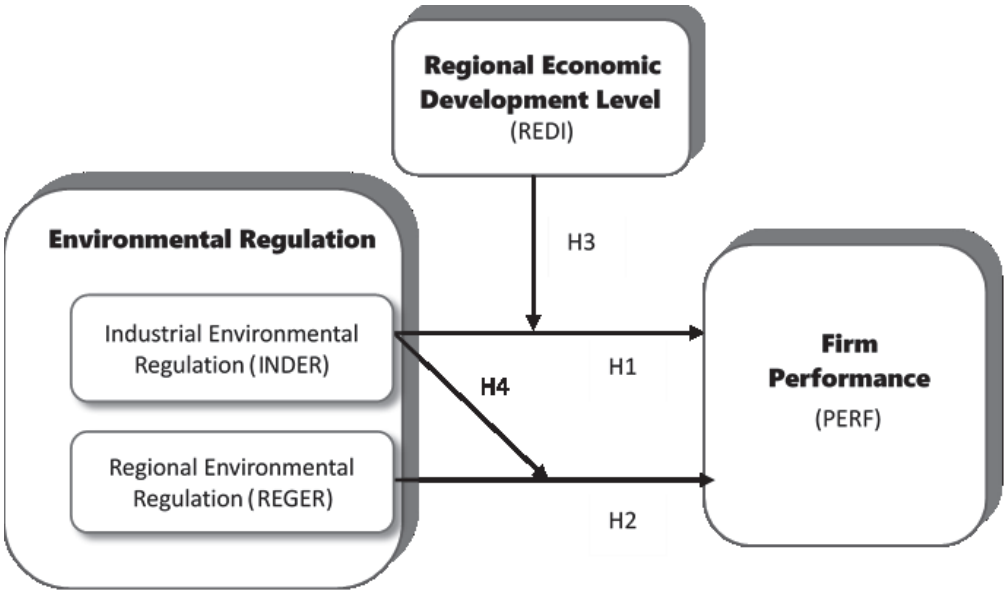

Fig. 1.Hypothesized conceptual model.

investment data from China's environmental database and constructed a measurement system for regional environmental regulation. Moreover, for environmental policy data, we used the research reports published by the Institute of Public and Environmental Affairs (IPE) and the Natural Resources Defense Council (NRDC), which have the annual evaluation data of the pollution information transparency index (PITI) of major cities in China. Finally, for unavailable data points, quarterly reports and annual reports of firms provided supplementary information. After eliminating potential singular values and error values, we built our final sample: time period of 2008-2015 and approximately 2664 observations from 333 manufacturing firms.

Variables

Dependent Variable

The dependent variable is Firm Performance (PERF). In this paper, the performance of firms is measured by the variation of sales level, because this index can best reflect the competitiveness of firms [33, 34]. In general, firm performance can be measured by indicators that include ROS, ROA, ROE, and Tobin Q [35]. However, the independent variables we used in this paper represent industrial environmental regulation and regional environmental regulation, which are not firm-specific characteristics. Therefore, it is unnecessary to consider the comparison between different firms, that is, the aforementioned indicators are not suitable enough for our study. Instead, sales level can better reflect the direct impact of environmental regulation on firm performance.

Independent Variables

The independent variables used in this paper are Industrial Environmental Regulation (INDER) and Regional Environmental Regulation (REGER). The first independent variable, the industrial environmental regulation per year, is measured by the ratio of the total annual pollutant treatment cost and pollution control investment to the total output value of the industry [21]. For each year, the industrial environmental regulation indicators are built as follows:

$$Industrial\ environmental\ regulation_{i,t} = \frac{W_{i,t}+P_{i,t}}{S_{i,t}} \tag{1}$$

where $W_{i,t}$ is the pollutant treatment cost of industry i in year t, $P_{i,t}$ is the total investment in pollution control of industry i in year t, and $S_{i,t}$ is the gross industrial output of industry i in year t. The operating cost of industrial pollutant treatment represents the industry's environmental regulatory constraints, and the total investment in pollution control reflects the willingness of the industry's environmental governance. The data of industrial environmental regulation are from China Industry Business Performance Data, which is one of the authentic databases for industry research.

The second independent variable, the regional environmental regulation, is measured by constructing a Cobb-Douglas' function:

$$Regional\ Environmental\ Regulation_{i,t} = \sqrt{Inv_{i,t} \times Sup_{i,t}} \tag{2}$$

where $Inv_{i,t}$ is the investment level of environmental governance of the region where firm i is located in year t, which is measured by the proportion of local government investment in environmental governance to GDP, and $Sup_{i,t}$ is the environmental supervision level of the region where firm i is located in year t, which is measured by the local government's "Pollution Information Transparency Index" (PITI). PITI is the environmental assessment data provided by the third-party assessment agencies, the Institute of Public and Environmental Affairs (IPE) and the Natural Resources Defense Council (NRDC). It reveals the transparency of pollution information and the implementation of policies in various cities in China, which can be used as an important indicator of environmental management (Wang & Zhang, 2019). In general, PITI includes five main indicators: daily supervision records (account for 30% of the total), self-disclosure of pollution sources (accounts for 26%), interaction between government and firms (accounts for 15%), emission data (account for 14%), and environmental impact assessment (accounts for 15%).

Control Variables

In this study, we controlled for a set of firm characteristics that can influence firm performance. We included the variable Firm Size (Size), which is measured by the total assets of firms. Compared with small-scale firms, large-scale firms have more funds to improve the operation and management level of firms, thus enhancing their performance, and larger firms can invest more funds in R&D to improve the level of firm technology [36], thereby improving firm performance.

We also included the variable Firm Type. It is measured by a dummy variable, Ownership, that is, 1 for firms with more than half of state-owned share, and 0 otherwise. Different ownership type of firms will significantly affect firm performance [37]. For firms with a high proportion of state-owned shares (SOEs), the agency problem is more serious, which will lead to inefficient supervision of managers of these firms, thus negatively affecting the financial performance of firms [38]. Also, state-owned firms not only need to meet business goals, but also need to meet some political goals [39], which will seriously hinder the improvement of firm performance. Therefore, this paper controls the firm type to mitigate its influence on firm performance.

We also controlled for the Average Profit Margin (AOPR). The variable AOPR is measured by the average profit margin of the firm in three years. This variable reflects the firms' ability to provide funds for the firms' operations and investment activities as well as provide important incentives for the firms' R&D investment behavior, which can also reflect the firms' potential of investing in R&D in the future [29], thereby affecting the long-term performance of firms.

The variable Firm Slack (Slack) is also included, which is measured by the ratio of current assets to current liabilities of firms. Firm slack reflects the adequacy of funds available to firms, and high slack will increase the flexibility of management [40], thus affecting firm performance. In addition, the idle resources of highly slack firms enable them to adapt to a complex competitive environment, which will significantly affect the company's business activities and performance [41].

To control the diversification of firms, we included the variable Diversity, measured by a dummy variable, that is, 1 for firms with diversified development, and 0 otherwise. There are two reasons that diversification can significantly affect firm performance. On one hand, moderate product diversification will improve firm performance, but higher product diversification will lead to a decline in firm performance [42]. On the other hand, a certain degree of diversification will help form a unique supply of resources for firms, to obtain a continuous "quasi-rent" from customers. However, once it exceeds a certain degree of diversification, it will increase the excess cost within the enterprise and cause damage to the firm performance [43].

Moderating Variables

The moderating variable in this paper is Regional Economic Development Level (REDI), measured by the per capita GDP of the company's location. This indicator reflects the status quo of the regional economic system and is a comprehensive concept that combines both space and process. Based on the principles of objectivity, dynamics, and feasibility, and with the purpose of obtaining an objective indicator that can not only reflect regional economic development trends and processes, but also distinguish the differences in regional economic development, we selected regional GDP per capita as a measurement of regional economic development level. We believed that there is a significant relationship between the level of regional economic development and the development of regional firms, because production technology level, product grade, and industrial level of local firms are closely related to the level of regional economic development, as well as the intensity and effects of firms' innovative investment. All these factors significantly affect firm performance.

Model

To test the above hypotheses, we constructed the following four multiple regression models:

$$PERF_{i,t} = \alpha_0 + \alpha_1 INDER_{i,t} + \alpha_2 INDER_{i,t}^2 + Controls_{i,t} + S_{i,t} + W_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$PERF_{i,t} = \alpha_3 + \alpha_4 REGER_{i,t} + Controls_{i,t} + S_{i,t} + W_{i,t} + \varepsilon_{i,t} \quad (4)$$

$$PERF_{i,t} = \alpha_5 + \alpha_6 INDER_{i,t} + \alpha_7 INDER_{i,t}^2 + \beta_1 INDER_{i,t} \times REDI_{i,t} + \beta_2 INDER_{i,t}^2 \times REDI_{i,t} + \beta_3 REDI_{i,t} + Controls_{i,t} + S_{i,t} + W_{i,t} + \varepsilon_{i,t} \quad (5)$$

$$PERF_{i,t} = \alpha_7 + \alpha_8 REGER_{i,t} + \beta_4 INDER_{i,t} \times REGER_{i,t} + Controls_{i,t} + S_{i,t} + W_{i,t} + \varepsilon_{i,t} \quad (6)$$

where $PERF_{i,t}$ is the firm performance of company i in year t, $INDER_{i,t}$ denotes industrial environmental regulation, $REGER_{i,t}$ represents regional environmental regulation, $REDI_{i,t}$ is the level of regional economic development, $INDER_{i,t} \times REDI_{i,t}$ denotes the interaction between industrial environmental regulation and regional economic development level, which is used to test the moderating effect of regional economic development level, $INDER^2_{i,t} \times REDI_{i,t}$ represents the interaction of the square term of industrial environmental regulation and the level of regional economic development, which is used to test the moderating effect of level of regional economic development on the curvilinear (inverted-U) relationship between industrial environmental regulation and firm performance, $Controls_{i,t}$ represents control variables, $S_{i,t}$ represents industry dummy variables, $W_{i,t}$ denotes unobservable firm-level factors, and $\varepsilon_{i,t}$ represents i.i.d error terms.

Results

This study's data analysis process is shown in Fig. 2.

Descriptive Statistics

Table 1 presents descriptive statistics of dependent, independent, and control variables used in our models. The industrial environmental regulation (INDER) ranges from -0.96 to 147, with an average value of 16.07, indicating that there are significant differences in environmental regulation intensity among different industries. Regional environmental regulation (REGER) ranges from 12 to 85, with an average value of 52.18, which also shows that there are obvious differences

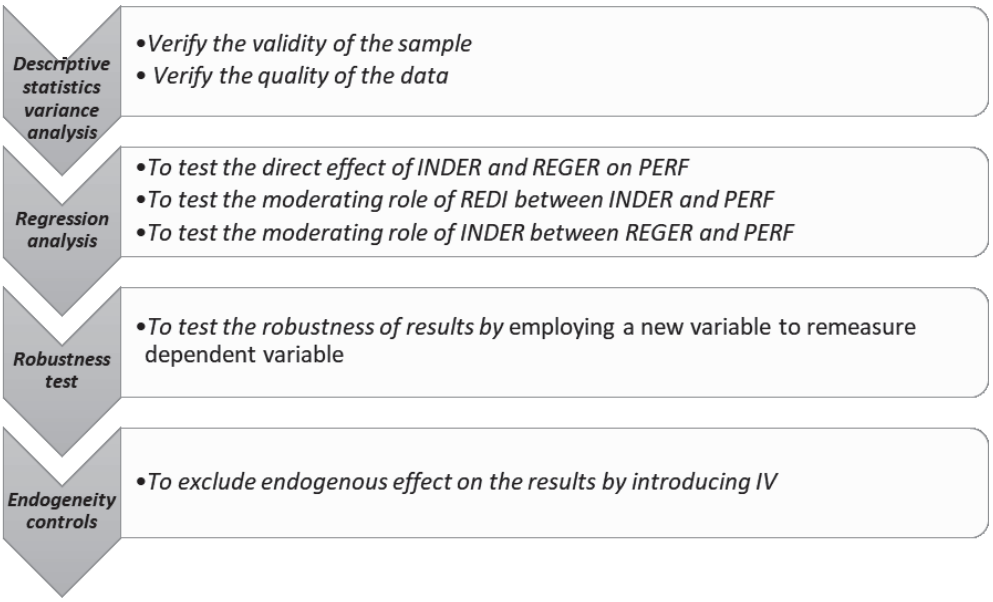

Fig. 2. The process of data analysis.

in the intensity of environmental regulation among different regions. As regards the regional economic development level (REDI), the minimum value is 9600 yuan and the maximum value is 470,000 yuan, which also depicts obvious differences in the regional economic development level.

Table 1 also lists the correlation coefficient matrix between various variables. The absolute value of most correlations is below 0.50, showing that strong multicollinearity is not an issue in our research framework. Furthermore, by checking the variance inflation factor (VIF) values, we find that all the VIF values are under 5, indicating that all VIF values are much lower than the commonly used threshold of 10 [44].

Regression Analysis

To address the moderating effects, all variables are standardized to alleviate the potential multicollinearity interaction terms [45]. Table 2 presents the empirical analysis results of this paper. Model 1 shows the linear relationship between industrial environmental regulation and firm performance, and there is a significant negative relationship between industrial environmental regulation and firm performance (0.35, p<0.01). Model 2 illustrates the nonlinear relationship between industrial environmental regulation and firm performance. Consistent with our expectations, there is a significant negative curvilinear relationship between industrial environmental regulation and firm performance (0.062, p<0.01). These results provide the first evidence that a certain degree of industrial environmental regulation is beneficial to the improvement of firm performance, but exceeding that certain degree will negatively affect firm performance. Therefore, Hypothesis 1 is verified. Although this is large enough to prove that there is a negative curvilinear relationship between industrial environmental regulation and firm performance, it is not strictly enough to prove that there is an inverted U-shaped curvilinear relationship between these two. To test whether this relationship is what we expected (inverted-U), this paper refers to the next two steps proposed by Lind and Mehlum [46]. First, we analyzed the slopes of curves at both ends of the data range, and the following tests are adopted:

$$\alpha_1 + 2\alpha_2 INDER_L > 0 \tag{7}$$

$$\alpha_1 + 2\alpha_2 INDER_H < 0 \tag{8}$$

where α_1 is the linear coefficient of industrial environmental regulation, α_2 is the quadratic coefficient of industrial environmental regulation, $INDER_L$ is the minimum values of industrial environmental regulation, and $NDER_H$ is the maximum values of industrial environmental regulation. If both conditions are met at the same time, it can be proved that there is a strict inverted U-shaped relationship between industrial environmental regulation and firm performance. After calculation, inequality (1) is 0.9779>0 (p = 0.000), inequality (2) is -18.228<0 (p = 0.000), which satisfy the above two conditions. Second, we investigate the turning point of the curve. The turning point is at $\alpha_1/2\alpha_2$ = 0.0008, and the change interval of the industry environmental regulation (INDER) is (-0.96, 147), we can conclude that the turning point is right within the interval, so the relationship between industrial environmental regulation and firm performance is strictly an inverted U-shaped.

Model 3 shows that there is a significant negative linear relationship between regional environmental regulation and firm performance (-0.005, ρ<0.1),

Table 1. Descriptive statistics and Correlation matrix.

Variable	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9
1.PERF	2.93	24.3	-250	660	1								
2.Size	59.3	232	2.3	5100	0.387*	1							
3.Ownership	0.24	0.429	0	1	0.051	0.226*	1						
4.Diversity	0.38	0.485	0	1	-0.048	-0.109*	-0.122*	1					
5.AOPR	0.09	0.155	-3.2	0.95	0.032	-0.032	-0.101*	0.039	1				
6.Slack	3.58	6.327	0.35	191	-0.032	-0.070*	-0.100*	0.071*	0.239*	1			
7.INDER	16.07	19.422	-0.96	147	-0.104*	0.099*	0.161*	-0.095*	-0.030	-0.070*	1		
8.REGER	52.18	15.850	12	85	-0.006	0.026	-0.163*	-0.075*	0.064*	-0.007	-0.062*	1	
9.REDI	8.29	6.195	0.96	47	0.009	0.026	-0.101*	-0.049	0.014	0.013	-0.058	0.043	1

Notes: The unit of regional economic development level is ten thousand yuan. * are significant at the level of 1%, N = 2664.

which is consistent with our expectation and verifies Hypothesis 2. In Model 4, we eliminate the curvilinear relationship between regional environmental regulation and firm performance by adding the quadratic term of industrial environmental regulation to the regression term already included in Model 3, in order to fully test Hypothesis 2. The result is consistent with our expectation, and there is no statistical significance between the quadratic term of regional environmental regulation and firm performance. This supports the assumptions of this paper, that is, regional environmental regulation negatively affects firm performance.

For the moderating effect in U-shaped relationships, there may be two cases: one is getting the curve flatter and the other is getting it steeper. Haans [46] suggests that the moderating effect in U-shaped relationships can be tested by the following model:

$$Y = \beta_0 + \beta_1 X + \beta_2 X^2 + \beta_3 XZ + \beta_4 X^2 Z + \beta_5 Z \quad (9)$$

where Y represents dependent variables, X denotes independent variables, and Z represents moderating variables. If β_4 is negative and significant, the moderating effect appears to steepen the inverted U-shape curve. To verify the moderating effect described in Hypothesis 3, this paper followed Haans' s suggestion [46] to add the interaction term between the industrial environmental regulation and both of the linear and quadratic terms of the regional economic development level, as well as the regional economic development level itself. As shown in Model 5, the interaction term between regional economic development level and quadratic term of industrial environmental regulation is significantly negative (-0.186, ρ<0.01), showing that the moderating effect steepens the inverted U-shape curve. To visually depict it, Fig. 3 shows the moderating effect of regional economic development level on the relationship between industrial environmental regulation and firm performance. As shown in Fig. 3, when the regional economic development level increases, the inverted U-shape relationship between industrial environmental regulation and firm performance becomes steeper. Thus, Hypothesis 3 is verified.

Furthermore, in order to test whether the level of regional economic development moderates the impact of regional environmental regulation on firm performance, we introduced Model 6, which includes regional environmental regulation, regional economic development level, and their interaction term. As is shown in Model 6, the interaction coefficient between regional economic development level and regional environmental regulation is not significant, indicating that there is no statistically significant interaction effect.

To test Hypothesis 4, we examined the moderating effect of industrial environmental regulation on the relationship between regional environmental regulation and firm performance through Model 6 in Table 2. The interaction term of industrial environmental

regulation and regional environmental regulation is added into Model 6, which also includes industrial environmental regulation and regional environmental regulation variables themselves. The results show that the interaction coefficient of environmental regulation and regional environmental regulation is significantly negative (-0.061, ρ<0.01), indicating that the moderating variable makes the slope of the relationship between regional environmental regulation and firm performance steeper, thus verifying Hypothesis 4. To visually depict it, Fig. 4 presents the moderating effect of industrial environmental regulation on regional environmental regulation and firm performance. This shows that with the increase of industrial environmental regulation,

Table 2. Main regression and moderating effect.

	(1)	(2)	(3)	(4)	(5)	(6)
	PERF	*PERF*	*PERF*	*PERF*	*PERF*	*PERF*
Size	0.224***	0.227***	0.221***	0.221***	0.232***	0.228***
	(0.018)	(0.017)	(0.019)	(0.019)	(0.017)	(0.018)
Ownership	-0.001	-0.002	-0.003	-0.003	-0.002	-0.002
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)
Diversity	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
AOPR	0.029*	0.029**	0.028*	0.028*	0.029**	0.028*
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Slack	-0.018	-0.019	-0.017	-0.016	-0.021	-0.016
	(0.024)	(0.024)	(0.025)	(0.025)	(0.024)	(0.025)
INDER	-0.035***	-0.0001			-0.024	0.017
	(0.006)	(0.013)			(0.018)	(0.017)
INDER²		-0.062***			0.018	
		(0.019)			(0.032)	
REGER			-0.005*	0.002		0.002
			(0.003)	(0.015)		(0.003)
REGER²				-0.006		
				(0.013)		
REDI					-0.007	
					(0.006)	
INDER×REDI					0.104**	
					(0.049)	
INDER²×REDI					-0.186***	
					(0.057)	
INDER×REGER						-0.061***
						(0.017)
Constant	0.257***	0.255***	0.258***	0.256***	0.256***	0.257***
	(0.012)	(0.012)	(0.012)	(0.013)	(0.012)	(0.012)
Ind FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N	2664	2664	2664	2664	2664	2664
R^2	0.204	0.224	0.157	0.157	0.241	0.216

Note: *, * *, * * * are significant at the level of 10%, 5% and 1%, respectively. Standard errors are in parentheses, and Ind FE represents industry fixed.

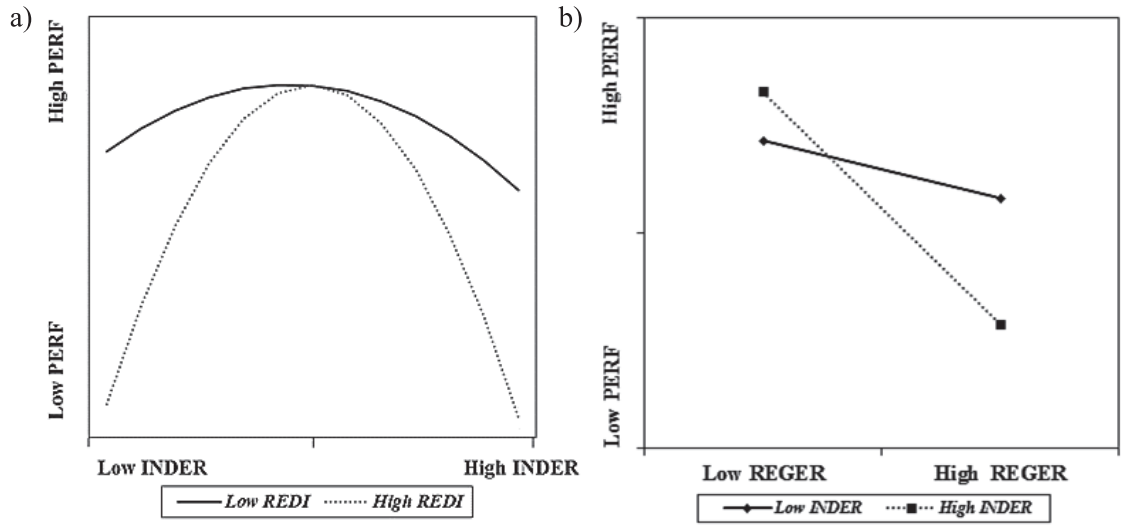

Fig. 3. a) Moderating effect of *REDI*; b) Moderating effect of *INDER*.

the negative relationship between regional environmental regulation and firm performance becomes steep. Consistent with Hypothesis 4, industrial environmental regulation partially replaces the influence of regional environmental regulation, which makes the high degree of industrial environmental regulation enhance its negative effect on firm performance.

Robustness Test

This study undertook further robustness tests by adopting alternative variables. First, we employed a new variable, current sales, to remeasure firm performance. Current sales reflects the current situation of firm performance, which is an important manifestation of business growth ability and can well measure the impact of environmental regulation on firm performance [47]. Table 3 shows the results of the robustness test. Model 2 indicates that there is a significant negative relationship between the quadratic term of industry environment regulation and firm performance (-0.021, ρ<0.05), which is consistent with the expectation of Hypothesis 1. Model 3 shows that there is a significant negative relationship between regional environmental regulation and firm performance (-0.003, ρ<0.01), which is consistent with the expectation of Hypothesis 2. In Model 5, the interaction coefficient between the quadratic term of industrial environmental regulation and the level of regional economic development is significantly negative (-0.07, ρ<0.01), which is consistent with the expectation of Hypothesis 3. As regards Model 6, the interaction coefficient between industrial environmental regulation and regional environmental regulation is not significant, but the negative coefficient is consistent with the conclusion of Hypothesis 4 (Z = -1.278, ρ = 0.201). Therefore, it can be concluded that the four hypotheses in this paper tend to be robust.

Endogeneity Control

The relationship between independent variables and dependent variables in this paper may have heterogeneous results that have not been observed for a long time. To address endogeneity caused by omitted variables, we introduced an instrument variable (IV) by employing a two-stage least-square method in this paper. As instrument, we followed the guideline proposed by Li [48] to build the framework:

$$INDER_{i,t}^{IV} = \left[PERF_{i,t} - Mean\left(PERF_{i,t}\right)\right] \times \left[INDER_{i,t} - Mean\left(INDER_{i,t}\right)\right] \quad (10)$$

$$REGER_{i,t}^{IV} = \left[PERF_{i,t} - Mean\left(PERF_{i,t}\right)\right] \times \left[REGER_{i,t} - Mean\left(REGER_{i,t}\right)\right] \quad (11)$$

where $INDER^{IV}_{i,t}$ is the instrument variable of industrial environmental regulation of firm i in year t, $REGER^{IV}_{i,t}$ is the instrument variable of regional environmental regulation of firm i in year t, $Mean(PERF_{i,t})$ is the average firm performance of firm i in year t, $Mean(INDER^{IV}_{i,t})$ is the average industrial environmental regulation of firm i in year t, and $Mean(REGER^{IV}_{i,t})$ is the average regional environmental regulation of firm i in year t. First, the validity of tool variables was tested and verified using Anderson canon. corr. LM statistic. The results are shown in Table 4. The Anderson canon. corr. LM statistic of each model is significant, rejecting the null hypothesis, indicating that the instrument variables are reliable. Second, we tested whether the instrument variable is weak using Cragg-Donald Wald F statistic. The results are shown in Table 4. The F value of each model is greater than 10, indicating that the instrument variable is not a weak one. Finally, we tested the validity of 2SLS. Using the Hausman test,

Table 3. Robustness test.

	(1)	(2)	(3)	(4)	(5)	(6)
	PERF	*PERF*	*PERF*	*PERF*	*PERF*	*PERF*
INDER	-0.002	0.012*			0.006	0.006
	(0.003)	(0.006)			(0.008)	(0.007)
$INDER^2$		-0.021**			0.004	
		(0.009)			(0.013)	
REGER			-0.003**	-0.002		-0.001
			(0.001)	(0.006)		(0.001)
$REGER^2$				-0.0001		
				(0.005)		
REDI					-0.004	
					(0.003)	
INDER×REDI					0.031	
					(0.021)	
$INDER^2 \times REDI$					-0.070***	
					(0.025)	
INDER×REGER						-0.009
						(0.007)
Ind FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Control	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N	2664	2664	2664	2664	2664	2664
R^2	0.890	0.891	0.890	0.890	0.892	0.890

Note: *, * *, * * * are significant at the level of 10%, 5% and 1%, respectively. Standard errors are in parentheses, and Ind FE represents industry fixed.

we find that the Hausman test result of each model is highly significant (ρ<0.01), indicating that 2SLS is effective.

Table 4 shows the results of 2SLS after eliminating endogenous problems. Model 2 demonstrates that the quadratic term of industrial environmental regulation has a significant negative relationship with firm performance (–1.617, ρ<0.01), which is consistent with the expectation of Hypothesis 1. Model 3 presents a negative relationship between regional environmental regulation and firm performance (–0.124, ρ = 0.162). Although the significance decreases, the coefficient is still negative, which is consistent with the expectation of Hypothesis 2. Model 5 indicates that the interaction between the quadratic term of industrial environmental regulation and regional environmental regulation is significantly negative (–6.406, ρ<0.01), which is consistent with the expectation of Hypothesis 3. In Model 6, the interaction between industrial environmental regulation and regional environmental regulation is significantly negative (–3.788, ρ<0.01), which is consistent with the expectation of Hypothesis 4. It can be concluded that after eliminating endogeneity, the four hypotheses are still valid.

Mechanism Analysis

According to Porter Hypothesis, appropriate environmental regulation will improve the capacity of technological innovation [49, 50], and then improve the firm performance. Therefore, firm technological innovation is the mediating variable between two kinds of environmental regulations (industrial environmental regulation and regional environmental regulation) and firm performance. The empirical results in the previous part have shown that there is an inverted U-shaped relationship between industrial environmental regulation and firm performance, and a negative relationship between regional environmental regulation and firm performance. Moreover, in order to test whether technological innovation is an intermediary mechanism, we use the patent applications as a proxy of the technological innovation [51-53], and analyze the intermediary mechanism based on the intermediary

Table 4. Endogenous test.

	(1)	(2)	(3)	(4)	(5)	(6)
	PERF	PERF	PERF	PERF	PERF	PERF
INDER	-0.576***	0.931***			-1.241***	3.318***
	(0.076)	(0.138)			(0.267)	(0.598)
$INDER^2$		-1.617***			2.699***	
		(0.229)			(0.581)	
REGER			-0.124	0.025		0.451***
			(0.089)	(0.064)		(0.082)
$REGER^2$				-0.028		
				(0.060)		
REDI					-0.396***	
					(0.085)	
INDER×REDI					4.896***	
					(1.038)	
$INDER^2$*×REDI*					-6.406***	
					(1.350)	
INDER×REGER						-3.788***
						(0.675)
Ind FE	*Yes*	*Yes*	Yes	*Yes*	*Yes*	Yes
Control	Yes	Yes	Yes	Yes	Yes	Yes
N	2664	2664	2664	2664	2664	2664
R^2	0.075	0.025	0.379	0.156	0.069	0.020
Hausman Chi	355.68***	368.6***	481.26***	126.63***	358.78***	827.33***
Anderson LM	80.948***	84.937***	2.185	3.284*	18.514***	34.756***
Cragg-Donald Wald F statistic	83.607	87.859	2.166	3.262	18.509	35.077

Note: *, * *, * * * are significant at the level of 10%, 5% and 1%, respectively. Standard errors are in parentheses, and Ind FE represents industry fixed.

effect model. The results are shown in Table 5. Model 2 shows that the coefficient of the squared term of industrial environmental regulation is significantly negative (–0.566, ρ<0.001), which shows that there is an inverted U-shaped relationship between industrial environmental regulation and technological innovation. Model 3 shows that the coefficient of regional environmental regulation is significantly negative (–0.014, ρ<0.1), which shows that regional environmental regulation significant negative affect technological innovation. Moreover, Model 5 shows that when introducing technological innovation and squared term of industrial environmental regulation at the same time, technological innovation is positively related to a firm performance. And Model 6 shows that when technological innovation is added to the regression model between linear term of regional environmental regulation and firm performance, technological innovation also has a significant positive relationship with firm performance. Based on the above analysis, technological innovation is an important channel for industrial environmental regulation and regional environmental regulation to affect firm performance, and the mediating effects have been tested.

Discussion and Conclusions

The purpose of this paper is to explore the impact of industrial environmental regulation and regional environmental regulation on the heterogeneity of firm performance. We find that the two variables, industrial environmental regulation and regional environmental regulation, are not independent of each other but interact with each other. Industrial environmental regulation will moderate the impact of regional environmental

Table 5. Mechanism analysis.

	(1)	(2)	(3)	(4)	(5)	(6)
	Innovation	*Innovation*	*Innovation*	*PERF*	*PERF*	*PERF*
INDER	-0.066***	0.871***		-0.030***	0.020**	
	(0.012)	(0.177)		(0.004)	(0.010)	
$INDER^2$		-0.566***			-0.100***	
		(0.210)			(0.017)	
REGER			-0.014*			-0.002
			(0.008)			(0.003)
Innovation				0.008	0.012*	0.015**
				(0.007)	(0.007)	(0.008)
Ind FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Control	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N	2664	2664	2664	2664	2664	2664
R^2	0.165	0.171	0.150	0.176	0.184	0.160

Note: *, * *, * * * are significant at the level of 10%, 5% and 1%, respectively. Standard errors are in parentheses, and Ind FE represents industry fixed.

regulation on firm performance. More specifically, our results showed that firms can replace part of regional environmental regulation by adapting to the supervision of industrial environmental regulation, thus changing the impact of regional environmental regulation on firm performance. A high degree of industrial environmental regulation will make the negative relationship between regional environmental regulation and firm performance steeper. At the same time, this paper finds that the influence of industrial environmental regulation on firm performance is not linear but an inverted U-shaped, namely, a certain degree of industrial environmental regulation will significantly promote firm performance; however, exceeding the certain degree will cause a negative impact on firm performance. Finally, this paper finds that the level of regional economic development will moderate the impact of industrial environmental regulation on firm performance. A high level of regional economic development will make the inverted U-shaped relationship between industrial environmental regulation and firm performance steeper, whereas a low level of regional economic development will make it flatter.

Research implications are as follows. (1) The effect of industrial environmental regulation is stronger than that of regional environmental regulation in the governance and rectification of highly polluting industries. A certain degree of industrial environmental regulation can stimulate firms to conduct technological innovation, reduce costs, enhance product competitiveness, and improve firm performance by developing new products and processes. However, regional environmental regulation has a negative effect on firm performance. Therefore, the state should focus on the introduction of reasonable, appropriate industrial environmental regulations for the rectification of firms in high-pollution industries, which will not only achieve better regulatory effects than regional environmental regulations, but also help improve firm performance and gain a win-win situation between environmental protection and firm performance improvement.

(2) The existing industrial environmental regulations need to be considered when the local government issues the corresponding policies and regulations on environmental governance of highly polluting firms. Industry environmental regulations will weaken the implementation effect of environmental regulations issued by local governments. Industrial environmental regulation, influenced by the attention of firms, will moderate the relationship between regional environmental regulation and firm performance and partially replace the role of regional environmental regulation. Regional environmental regulation will negatively affect firm performance and reduce enterprise income. For those firms that have fully followed the national industrial environmental regulation standards, the government should offer certain support subsidies. Through government's support for certain types of firms, the government can, to some degree, guide social investment and technical resources to invest in these firms. Only by following this will firms devote themselves to technological innovation while adhering to environmental regulations, thus finally achieving the win–win goal of protecting the environment and improving firm performance.

(3) High-polluting firms can avoid the influence of industrial environmental regulations by migrating to economically underdeveloped areas for development.

Regions with a relatively low level of economic development weaken the influence of industrial environmental regulations on firm performance. By weakening the negative effect of strict industrial environmental regulations followed by highly polluting firms, and reducing the cost of enterprise environmental compliance, firms located in such regions will eliminate the resistance behavior of highly polluting firms, make them actively follow and implement environmental regulations, attain the goal of environmental pollution control, and finally achieve a win–win situation between environmental protection and firm performance.

Similar to other studies, this study also has its shortcomings, thus opening the way for future research. First, due to the limited access of data, this study does not consider the heterogeneous effects of industrial environmental regulation and regional environmental regulation on the firm performance of state-owned firms and non-state-owned firms. Because of the difference in the degree of political connections, firms of a different type will inevitably lead to different implementation effects of environmental regulation policies, which will result in different effects on firm performance. Second, this paper focuses on the impact of different environmental regulations on firm performance. Future research can study further into the innovation performance of firms, a highly valuable aspect. Firm performance focuses on the downstream of the value chain, while innovation performance focuses on the upstream of the value chain. Through a comprehensive analysis, including the whole R&D process and the commercialization process within the enterprise, future studies can explore the overall impact of different environmental regulations on the upstream and downstream of the enterprise value chain, as well as discuss the policy heterogeneity of environmental regulations, which is more valuable for the whole value chain.

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Conflicts of Interest

Authors declare that they do not have any competing financial, professional, or personal interests from other parties.

Appendix A

Highlight:

1. We explore how different types of environmental regulations affect firm performance.
2. Regional environmental regulations are negatively related to firm performance.
3. Industrial environmental regulationsand and PERF are inverted U-shaped relationship.
4. INDER and REGER significantly interact with each other.
5. Regional economic development affects INDER and PERF’s. inverted U-shaped.

Appendix B

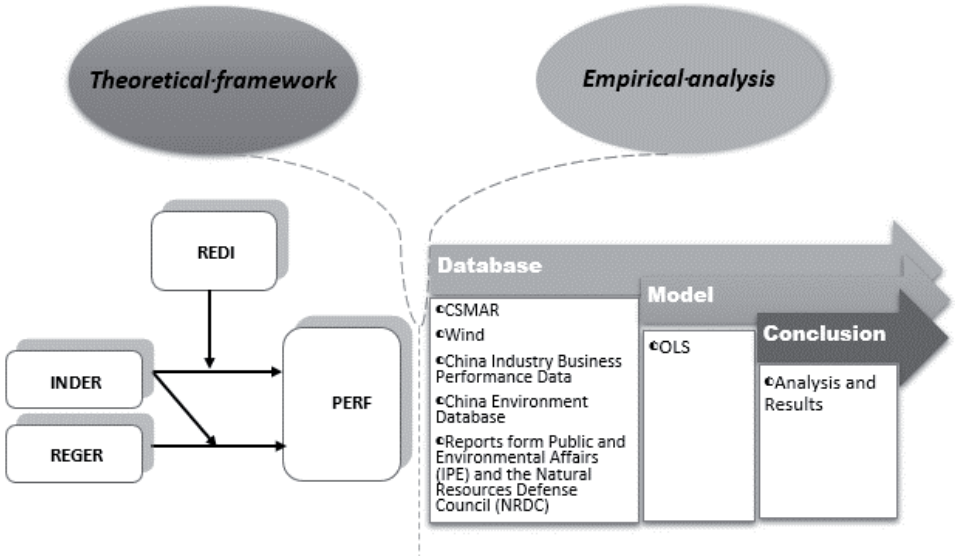

Fig. A1. Graphical abstract.

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