

The Influence of Environmental Regulation on The Innovation of Heavily Polluting Enterprises

-- Mediation Effect Test Based on Financing Constraints

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Abstract: This paper selects the listed companies of heavy pollution manufacturing industry in SSE and Shenzhen Stock Exchange from 2014 to 2018 as samples, and establishes A step-by-step regression model to explore the relationship between environmental regulations, financing constraints and enterprise innovation, aiming to provide reference for the realization of green and innovative development of enterprises. The study found that the intensity of environmental regulation significantly suppresses the innovation of heavily polluting enterprises. Then the cost of environmental protection investment of enterprises will increase, which may cause the shortage of disposable funds of enterprises, which will reduce the R & D investment in the relationship between environmental regulation and enterprise innovation, indicating that part of the influence of environmental regulation on enterprise innovation is realized through financing constraints.

Keywords: Environmental regulation; Enterprise innovation; Financing constraints.

1. Introduction

Over the past 40 years of reform and opening up, China's per capita GDP has increased by more than 25 times. However, the long-term rugged development model has increased the burden of the environment, and the development concept of "GDP theory" runs counter to the call for ecological civilization that "clear waters and green mountains are gold and silver mountains". To alleviate the unbalanced economic growth, uncoordinated, unsustainable contradiction, the Chinese government in the eighteenth big, 19 report and "made in China 2025" planning are put forward to promote green development and circular development, comprehensively promote resource consumption, pollution emissions of extensive manufacturing to green manufacturing, and cooperate with the "environmental protection law of the People's Republic of China" and a series of policies and regulations.

Enterprises are the object of the direct effect of government regulation, and the implementation of a series of environmental regulation policies will inevitably increase certain economic constraints to enterprises. Therefore, although environmental regulation will improve the ecological environment, it will also have an impact on the economic development. From the perspective of economics, the academic circle has different views on whether environmental regulation and economic development can achieve "win-win". On the one hand, represented by the neoclassical economics "restriction hypothesis" points out that tighter environmental policy will lead to rising pollution costs of producers, when resource conditions remain certain, high cost will change the enterprise resource allocation, lead to reduce investment in research and development activities, reduce production efficiency, and curb the economic growth. On the other hand, in the 1990s, Porter et al reached the opposite conclusion, the Porter hypothesis. The hypothesis is that from a long-term and dynamic perspective,

environmental regulation can effectively promote manufacturers to carry out innovative activities and improve production profits, which can not only compensate the input cost of environmental protection, but also improve the productivity and competitiveness of enterprises. Later, Jaffe and Palmer decomposed the Porter hypothesis into "weak Porter hypothesis", "narrow Porter hypothesis" and "strong Porter hypothesis". The first version believes that reasonably designed environmental regulations can stimulate technological innovation activities; the second version means that the flexible environmental regulation policies and means can provide more impetus for innovation than normative and binding policy means; and the third version suggests that the innovation effect of environmental regulations can cover the total cost of enterprises, leading to the increased business performance and competitiveness of enterprises.

For environmental protection and the sustainable economic development, enterprise innovation has important strategic significance, which is the key element to realize the beneficial situation of sustainable economic development and environmental protection. Financing is an important factor to improve the environmental behavior of enterprises, which has an indirect impact on the sustainable development of the environment, and capital will have an impact on the enterprise's environmental strategy. Innovation and improvement of the ecological environment cannot be achieved overnight, which requires a large amount of sustained and stable financial support. If the internal financing is insufficient or the external financing channels are not smooth, the innovation activities of enterprises to respond to environmental regulations will be limited. At the same time, different internal factors such as enterprise ownership structure have different perception of environmental pressure and financing constraints. It can be seen that the study of the relationship between environmental regulation, financing constraints and enterprise innovation has certain practical significance. Studying the influence of government environmental regulation on the behavior of enterprises in

heavy pollution industries is of great practical significance for the construction of ecological civilization and "beautiful China".

This paper selects the 2014-2018 Shanghai stock exchange and Shenzhen stock exchange A-share heavy pollution manufacturing listed companies as A sample, the influence of environmental regulation and financing constraints on enterprise innovation mechanism of empirical analysis, and the financing constraints as the intermediary variable, using the intermediary effect model in the environmental regulation and enterprise innovation, in order to governments at all levels and relevant departments to provide reference, promote the development of ecological environment and economic quality go hand in hand.

In this paper, it is found that the intensity of environmental regulation has a significant inhibitory effect on the R & D innovation of heavily polluting enterprises. When the environmental regulation intensity is large, the environmental protection investment cost of enterprises will increase, which may cause the shortage of disposable funds of enterprises, which will reduce the R & D investment level of enterprises, and play the role of some intermediaries in the relationship between environmental regulation and enterprise innovation, indicating that part of the influence of environmental regulation on enterprise innovation is realized through financing constraints.

2. Literature Review and Research Hypotheses

2.1. The impact of environmental regulation on enterprise innovation

As the internal and external driving force of enterprise value growth and green development, the relationship between environmental regulation and enterprise innovation has been highly concerned by the academic and practical circles and has conducted a series of relevant studies. At present, the academic community has not reached a consensus in the research conclusions on the impact of environmental regulation on enterprise innovation. There are mainly the following three views:

First, environmental regulation can encourage enterprises to increase investment in innovation. The Porter hypothesis systematically expounds the possibility of win-win results between environmental protection and improving enterprise competitiveness, and points out that strict and reasonable environmental regulation can promote enterprise innovation, so as to obtain innovation compensation to compensate for the cost increase caused by environmental regulation. Li Yuanyuan et al. studied the relationship between environmental regulation and technological innovation by using the relevant data of Chinese A-share listed companies from 2013 to 2017, and the results showed that there is a positive non-linear relationship between environmental regulation and enterprise technological innovation, and showed the characteristics of diminishing marginal efficiency. MiaoMiao using principal component analysis and intermediary effect model, found that the stronger the environmental regulation, the higher the enterprise innovation ability, and financing constraints in the relationship between environmental regulation and enterprise innovation play a significant part of the intermediary role, namely the part of the environmental regulation on enterprise innovation is achieved by easing enterprise external financing constraints.

CAI Wuche and Li Qingqing used the data of 30 provinces in China from 2005 to 2015 to study the impact of environmental regulation on ecological technology innovation of enterprises. The results showed that environmental regulation would have a positive impact on ecological technology innovation of enterprises through R & D investment. Yu Kexin et al. took three A-share listed companies from 2014 to 2017 as samples and studied the role of environmental regulation on green technology innovation of enterprises. The results showed that for the vast majority of resource-based enterprises, environmental regulation plays A positive role in promoting green technology innovation.

Second, environmental regulation has a crowding-out effect on technological innovation investment. The strengthening of environmental regulation leads to the increase of the cost of pollution control in enterprises and cannot be fully compensated, which is bound to restrict or occupy other types of investment, which may lead to the reduction of R & D investment and production scale of enterprises, and support the traditional neoclassical theory. Dean & Brown used the relevant data of Swedish paper enterprises as a sample, and found that the stronger the degree of environmental regulation, the higher the production cost of enterprises, so that the environmental regulation has a negative impact on the innovation investment of enterprises. Wagner Using the German manufacturing enterprises to study the relationship between environmental regulation and enterprise technology innovation, we found that there is a negative correlation between environmental regulation and enterprise green technology innovation. Kneller et al., taking the British manufacturing industry from 2000 to 2006, empirically tested the "crowding out effect" of environmental regulation. He Wuji et al. verified the green tax, that is, the inhibition of energy consumption and environmental pollution, that the sewage fee has not reflected the green innovation transformation of enterprises, and cannot significantly promote the improvement of technological innovation level.

Third, the impact of environmental regulation on enterprise technology innovation investment is uncertain. In addition to the two influence mechanisms above, there are no significant correlation and different non-linear relationships based on different types of environmental regulation. Frondel Through research, we found that command-controlled environmental regulation plays a role in promoting the development of pollution terminal technology, but it has no obvious effect on cleaner production technology, while market-incentive environmental regulation cannot play an obvious role in both. The studies of Shui Huili and others found that environmental regulation based on pollution control had a crowding out effect on the R & D investment of heavily polluting enterprises, while environmental regulation based on energy consumption management significantly promoted the R & D investment of cleaner production enterprises. Ding Xin et al. used the Tobit panel regression model for empirical analysis, and found that the intensity of environmental regulation showed A significant "U" -shaped relationship with the R & D investment and the number of patent applications of Chinese A-share listed companies. Based on two environmental regulation types of cost and investment, Zhang Ping empirically studied the influence of different environmental regulation types on enterprise technological innovation. The research shows that cost environmental regulation will produce "crowding out effect" on enterprise

technological innovation and have certain inhibitory effect; The influence of investment environmental regulation on enterprise technological innovation is consistent with the "Porter hypothesis" and can promote the technological innovation of enterprises to some extent.

Therefore, although a lot of achievements have been made in the research on the impact of environmental regulation on technological innovation at home and abroad, no complete consistent conclusion has been reached.

In summary, the following assumptions are proposed:

$H1_a$: There is a significant positive correlation between environmental regulation and enterprise innovation.

$H1_b$: There is a significant negative correlation between environmental regulation and enterprise innovation.

2.2. Mediating effect based on financing constraints

For the relationship between financing constraints and enterprise innovation, domestic and foreign scholars have done a series of research. Efthyvoulou & Vahter used innovative enterprises in 11 European countries to investigate and study, and found that there is a negative correlation between financing constraints and the innovation performance of enterprises, and financing constraints are an important reason for the reduction of the innovation performance of enterprises. Silva & Carreira takes Portuguese companies as the research object to analyze the obstacle degree of financing constraints to enterprise innovation. The results show that enterprises will be negatively affected by financing constraints in the process of R & D and innovation, and financing constraints will reduce the innovation investment of enterprises. Liu Shengqiang et al. used the Euler equation and the bilateral stochastic boundary method to study the impact of financing constraints and agency costs on the R & D investment of enterprises, and found that the financing constraints showed a significant negative correlation with the R & D investment of enterprises, and its existence would lead to the insufficient R & D investment of enterprises. Zhou Kaiguo and others used the sample of Chinese enterprises in the World Bank questionnaire, and found that financing constraints could restrain enterprises when facing fierce product and market competition. Sheng Dan et al. explored the impact mechanism of environmental regulation from the perspective of social responsibility and environmental information disclosure, and believed that the main transmission path comes from easing the financing constraints of enterprises to promote the technological innovation of enterprises. Some scholars have also found that financing constraints and the positive relationship between enterprise innovation, such as Wang Wanqiu and XingYue to a-share listed companies as A sample, studied the financing constraints will restrict technology after R & D investment, the results show that the high degree of financing constraint after investment in technology R & D will increase, because they tend to use non-cash payment. Lou Changlong and Ran Maosheng studied the impact of financing constraints on technological innovation with the sample of listed companies in the heavy pollution industry. The results show that lower financing constraints can promote the technological innovation of enterprises, and compared with external financing, internal financing has a more obvious promoting effect. Miao Miao and other studies found that financing constraints play a significant intermediary role in the

relationship between environmental regulation and enterprise technological innovation, that is, the government's strengthening of environmental regulation can effectively alleviate the external financing constraints faced by enterprises, so as to help enterprises to further improve their technological innovation ability.

According to the optimal order financing theory, the internal retained profit of an enterprise is the main source of financing for the enterprise. However, when the internal capital of an enterprise cannot meet the financing needs, the external financing should be used. Enterprise R & D activities have the disadvantages of high risk, long cycle, much capital consumption and information asymmetry, which makes enterprise R & D activities more likely to fall into financing difficulties compared with other activities. The ecological development of traditional industries and the development of new green ecological industries are inseparable from financial support. Under the premise of environmental regulation, the degree of enterprise financing constraint may be further improved. Enterprise innovation process from the initial formation to the final commercialization after a certain cycle, and it is difficult to grasp the final benefit, thus enterprise R & D has a higher adjustment cost, lead to most green innovation project to reach the average profit level of commercial Banks, commercial Banks did not enjoy other additional business interests in the field of green, so the green project faces more serious problem of credit discrimination. Banks' refusal of enterprise green investment projects seriously restricts the allocation and conversion efficiency of enterprise funds. As a result, some enterprises are unable to cope with the cost impact caused by environmental policy tightening due to lack of funds, and their technological innovation ability is further suppressed.

However, moderate financing constraints may have synergistic effects with the environmental regulation of enterprises, and jointly promote the technological innovation of enterprises, and technological innovation can further enhance the ability of enterprises to absorb new capital, thus entering a virtuous cycle. On the one hand, the root cause of financing constraints is information asymmetry, and the environmental information disclosure of enterprises will become more comprehensive and transparent with the strengthening of the government's environmental regulation. In 2017, a total of 857 companies disclosed environmental information in Shanghai and Shenzhen, an increase of 47 compared with 2016, accounting for 24.59% of the number of listed companies. Environmental information disclosure will guide investors to pay attention to the application of technologies in energy conservation and emission reduction, environmental pollution, clean energy, environmental protection products and other aspects, and be more able to obtain financing support from legal financial institutions to be used in research and development activities. On the other hand, higher environmental regulation and better implementation effect, which usually reflects that the region has a more perfect institutional environment, that is, a higher level of marketization, which is conducive to improving the financial system and promoting the development of the financial market. Existing literature has shown that more developed financial markets, more complete systems and better environment are often more able to reduce the external financing costs of companies, so as to improve the financing constraints they face.

In conclusion, the following assumptions are proposed:

H2: Financing constraint plays an intermediary role in the influence of environmental regulation on enterprise innovation.

The intermediary effect model of "environmental regulation- -financing constraint- -enterprise innovation" constructed in this paper is shown in Figure 1.

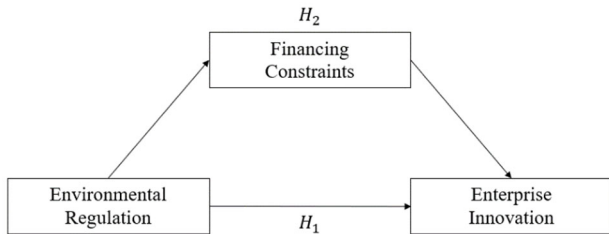


Figure 1. The mediation effect model of "Environmental Regulation-Financing constraint-Enterprise Innovation"

3. Research Design

3.1. Sample Selection and Data Source

This paper samples and screens the a-share listed companies of the Shanghai Stock Exchange and Shenzhen Stock Exchange in heavy pollution industries from 2014 to 2018. First in accordance with the relevant national standards will heavy pollution industry as mining industry (B), food and beverage industry (C0), textile, clothing, fur (C1), wood, materials, furniture (C2), paper making, printing (C3), oil, chemistry, plastic, plastic (C4), metal, non-metal (C6), medicine, biological products (C8), electricity, gas and water production and supply (D) nine industries. Eliminate ST companies. Delete missing data samples and obtain a total of 2790 sample values over 5 years. In order to reduce the deviation of outliers on the empirical results, this paper reduces the 1% and 99% scales for all variable data. The data needed for this study are from Taian Database, China Statistical Yearbook, China Statistical Yearbook of Environmental Statistical Yearbook and China Urban Statistical Yearbook. The collected data were preprocessed by Excel software, and then further descriptive statistics and regression analysis were done by the measurement software Stata 16.0.

3.2. Variable design

3.2.1. Explained Variable

This paper takes the enterprise R & D investment as the agency index of enterprise innovation. Existing literature usually treats it as the proportion of R & D investment in operating income or total assets, the natural logarithm of R & D investment, etc. In theory, the strengthening of environmental regulation will stimulate companies to increase the absolute amount of R & D investment. Therefore, this paper refers to the practice of Li Tao and Li on. In this paper, we use the natural logarithm of R & D investment in order to measure the enterprise innovation ability, which is expressed by the symbol RDS.

3.2.2. Explanatory Variable

For environmental regulation, the relevant data of this variable is difficult to obtain and the data quality is relatively weak, and the academic community has not reached a unified measurement standard. Currently for environmental regulation measure mainly has qualitative and quantitative

two ways, because the qualitative method has certain subjectivity, index selection is more random, may make the results deviation, therefore, this article reference Ren Xiaosong, using entropy method and principal component analysis of industrial wastewater emissions, industrial SO₂ emissions and industrial soot emissions for environmental pollution emissions comprehensive index quantitative measurement:

(1) Standardize these three contaminants:

$$UE_{ij}^s = [UE_{ij} - \min(UE_j)] / [\max(UE_j) - \min(UE_j)]$$

Among them, UE_{ij}^s is the standardized result of the index, UE_{ij} is the unit output value of class j pollutants in province i, $\min(UE_j)$ represents the minimum value of unit output value of class j pollutants in all provinces, and $\max(UE_j)$ represents the maximum value of unit output value of class j pollutants in all provinces.

(2) Take the weight of each pollutant:

$$W_j = UE / \overline{UE_j}$$

$\overline{UE_j}$ represents the average level of unit output value of j pollutant in province i in each year;

(3) The environmental regulatory composite index is obtained from the product of weights and standardization:

$$ER_i = \frac{1}{3} \sum_{j=1}^3 W_j UE_{ij}^s$$

ER_i is the comprehensive index of environmental regulation in province i.

(4) According to the information of the province to which the sample enterprise belongs, the ERI of the sample enterprise is matched. The larger ERI, the more pollution emissions and the weaker environmental regulation.

The above relevant data are from China Statistical Yearbook, China Environmental Statistical Yearbook and China City Statistical Yearbook.

3.2.3. Mediator Variable

Due to the complexity of corporate financing constraints, a variety of financial indicators will have an indirect impact on them, so most scholars use multivariate indices to measure corporate financing constraints, such as KZ index, WW index, SA index. Among the three, the KZ index and WW index contain many endogenous financial variables, such as cash flow, leverage, industrial enterprise scale, etc., and financing constraints and financial variables such as cash flow, industrial enterprise leverage, and industrial enterprise scale determine each other. Because the SA index method can effectively overcome the disadvantages of the WW index and KZ index containing endogenous variables. Therefore, this paper uses the SA index to construct the financing constraint index (FC). A higher value for FC indicates a lower degree of financing constraint on the business. The SA index was originally proposed by Hadlock & Pierce, who found that the size and age of firms are particularly useful indicators for measuring the level of financing constraints, with the expression as $SA = -0.737 \times SI + 0.043 \times SI^2 - 0.040 \times A$, where SI is the natural logarithm of the company's total assets, A is the company's number of years on the market, and SA is negative.

3.2.4. Controlled Variable

In order to effectively control various factors that may affect enterprise innovation, this paper selects the following variables that affect the characteristics of enterprises as control variables based on existing research: profitability

(ROA), cash flow (CF), investment opportunity (OPP), company age (AGE), equity structure (LS1), and asset size (SIZE). Considering that enterprises with higher growth potential will bring more internal cash flow, this paper introduces the ratio of net profit to average total assets as a variable to judge the profitability of enterprises. Since not only the internal cash flow of an enterprise can affect the

degree of financing constraints of the enterprise to a certain extent, but also the size of the enterprise will also affect the degree of its financing constraints to a certain extent, this paper adds the scale of the enterprise to the variables. Table 1 shows the definition of related variables and how they are calculated.

Table 1. Variable Definitions

Type of variable	Variable Name	Variable Symbol	Meaning and Description of the Variables
Explained Variable	Enterprise Innovation	RDS	The R & D investment of enterprises takes the natural logarithm
Explanatory Variable	Environmental Regulation	ERI	Comprehensive index of environmental regulation
Mediator Variable	Financing Constraints	FC	The absolute values of the SA index were taken as the natural log
Controlled Variable	Profitability	ROA	Net profit / average total assets
	Cash Flow	CF	Cash flow from operating activities/total assets at the end of last period
	Investment Opportunity	OPP	Tobin's Q value, namely: the market value of the company / (total assets-net intangible assets-net goodwill)
	Company Age	AGE	The length of time that the company was founded
	Ownership Structure	LS1	Proportion of the company's largest shareholder shareholding
	Asset Size	SIZE	Ln (Total assets at the end of the year)

3.3. Empirical model construction

To test the hypothesis $H1_a$ and $H1_b$, the following model (1) was constructed:

$$RDS = \alpha_0 + \alpha_1 ERI + \alpha_2 ROA + \alpha_3 CF + \alpha_4 OPP + \alpha_5 AGE + \alpha_6 LS1 + \alpha_7 SIZE + \varepsilon \quad (1)$$

If $\alpha_1 > 0$ is true and significant, the hypothesis $H1_a$ holds; If $\alpha_1 < 0$ is true and significant, the hypothesis $H1_b$ holds.

To test the hypothesis $H2$, the following model (2) and (3) was constructed:

$$ERI = \beta_0 + \beta_1 FC + \beta_2 ROA + \beta_3 CF + \beta_4 OPP + \beta_5 AGE + \beta_6 LS1 + \beta_7 SIZE + \varepsilon \quad (2)$$

$$RDS = \delta_0 + \delta_1 ERI + \delta_2 FC + \delta_3 ROA + \delta_4 CF + \delta_5 OPP + \delta_6 AGE + \delta_7 LS1 + \delta_8 SIZE + \varepsilon \quad (3)$$

Model (1) (2) (3) is used to test the intermediary effect of financing constraints. The specific procedures are as follows:

The first step is to directly use environmental regulation to return to enterprise innovation and test the main effect. If α_1 is significant, the hypothesis $H1_a$ or $H1_b$ is true, and the next test can be carried out, in which case α_1 is the total effect of environmental regulation on enterprise innovation. If α_1 is not significant, the hypothesis $H1_a$ or $H1_b$ doesn't hold, stop subsequent inspection steps.

The second step is to use environmental regulations to regress financing constraints and determine whether the β_1 is significant.

In the third step, environmental regulation and financing constraints are included in the regression equation as explanatory variables to regress enterprise innovation, and when the previous step is considered, when β_1 and δ_2 are significant and δ_1 are not significant, it indicates that financing constraints have a complete mediating effect between environmental regulation and enterprise innovation; If δ_1 is significant, it means that financing constraints play a partial intermediary role; If at least one of β_1 and δ_2 is not significant, the Sobel test is required for the next test. If the mediation effect is tested for existence, the hypothesis $H2$ holds.

4. Empirical Results and Analysis

4.1. Descriptive analysis

Descriptive statistics for the study variables are shown in Table 2. As can be seen from Table 2, the average value of the natural logarithm of R & D investment is 17.95, about 62.46 million yuan, but the standard deviation is 1.374, indicating that the annual R & D investment of different companies is large, with the minimum value of 14.24 (about 1.53 million yuan) and the maximum value of 21.15 yuan (about 2.2 billion yuan). For environmental regulation, the minimum and maximum values of the comprehensive index are 0.000301 and 2.585 respectively, and the standard deviation is 0.650, indicating that different enterprises in different provinces attach different importance to environmental regulation, and the environmental regulation of the sample is quite different. The mean value of the financing constraint index was 1.334, the minimum value was 1.134, the maximum value was 1.469, and the standard deviation was 0.0576, indicating that the financing constraint generally existed in the sample enterprises.

Table 2. Descriptive Statistics of the Variables

Variable name	Sample Size	Mean	sd	Min	Max
RDS	2,790	17.95	1.374	14.24	21.50
ERI	2,790	0.729	0.650	0.000301	2.585
FC	2,790	1.334	0.0576	1.134	1.469
ROA	2,790	0.0417	0.0560	-0.158	0.212
LS1	2,790	35.26	14.21	10	74.89
OPP	2,790	1.976	1.569	0.188	8.441
CF	2,790	0.0666	0.0724	-0.144	0.274
AGE	2,790	11.55	6.095	2	24
SIZE	2,790	22.50	1.222	20.41	26.31

4.2. Multiple Regression Analysis

The regression results of this model are as follows:

4.2.1. Regression Analysis of Environmental Regulation on Enterprise Innovation

The regression results of model (1) are shown in Table 3. The coefficient of the environmental regulation composite index is 0.126, which is significant at the confidence level of 1%, indicating that the larger the environmental regulation composite index, the smaller the environmental regulation strength, the more enterprise R&D investment, and the negative correlation between environmental regulation and enterprise innovation, which confirms that the $H1_b$ is true and the $H1_a$ is not established. The possible reason may be that for heavily polluting enterprises, when the force of environmental regulation is too great, the pressure from the government's policies related to environmental pollution control makes the pollution control expenses incurred by enterprises to avoid political costs crowd out R&D investment funds to a certain extent, reduce the intensity of R&D investment, so that there is a significant negative correlation between environmental regulation and enterprise innovation.

Table 3. Regression results of Model (1)

Variables	Model (1) RDS
ERI	0.126*** (3.811)
ROA	3.190*** (6.805)
LS1	-0.00441*** (-2.749)
OPP	-0.0225 (-1.299)
CF	0.721** (2.089)
AGE	-0.0232*** (-6.208)
SIZE	0.668*** (29.35)
Constant	3.118*** (6.190)
Observations	2,790
R-squared	0.347

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; t value is given in parentheses.

4.2.2. Regression Analysis of the Mediation Effects of Financing Constraints

Table 3 shows that the coefficient of the environmental regulation composite index is significantly positive at the confidence level of 1% ($\alpha_1 = 0.126$, $p < 0.01$), indicating

that the main effect is significant.

The regression results for model (2) and model (3) are shown in Table 4. When the financing constraint is regressed by environmental regulation, the coefficient of the comprehensive index of environmental regulation is significantly positive ($\beta_1 = 0.00265$, $p < 0.1$), indicating that the larger the comprehensive index of environmental regulation, the lower the intensity of environmental regulation, the larger the financing constraint index FC, the lower the level of financing constraint, and there is a significant positive correlation between the intensity of environmental regulation and the level of financing constraint. When environmental regulation and financing constraints are added to the regression equation to regress to enterprise innovation, the coefficient of the financing constraint index is significantly positive ($\delta_2 = 1.403$, $p < 0.01$), indicating that the indirect effect is significant, the larger the financing constraint index FC, the lower the level of financing constraint, the greater the R&D investment expenditure of enterprises, and the level of financing constraint and enterprise innovation are significantly negatively correlated. If the coefficient of the environmental regulation composite index is significantly positive ($\delta_1 = 0.122$, $p < 0.01$), then financing constraints have some mediating effects in the relationship between environmental regulation and enterprise innovation, so it is assumed that $H2$ is true.

Table 4. Regression results of Model (2) and Model (3)

Variables	Model (2) FC	Model (3) RDS
ERI	0.00265* (1.959)	0.122*** (3.701)
FC		1.403*** (3.031)
ROA	0.0984*** (5.134)	3.052*** (6.489)
LS1	-0.000560*** (-8.523)	-0.00363** (-2.235)
OPP	-0.00492*** (-6.963)	-0.0155 (-0.893)
CF	-0.00578 (-0.409)	0.730** (2.115)
AGE	0.00535*** (34.97)	-0.0307*** (-6.857)
SIZE	-0.0203*** (-21.86)	0.696*** (28.32)
Constant	1.754*** (85.12)	0.657 (0.688)
Observations	2,790	2,790
R-squared	0.377	0.349

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; t value is given in parentheses.

5. Robustness Test

Considering that there may be collinearity problems between variables, this paper calculates the variance inflation factor and obtains a mean VIF of 1.53, indicating that there is basically no multicollinearity problem in the regression equation.

Since the regression results of β_1 and β_2 are significant, there is no need to use the Sobel test for the next test. In order to ensure the reliability of the regression results,

this paper tests the robustness of the model by adding or subtracting control variables.

Firstly, on the basis of the original model, two control variables are added as gearing ratio (L) and operating income growth rate (GROWTH), and the regression results are shown in Table 5. It can be seen that there is still a significant negative correlation between environmental regulation and enterprise innovation, and financing constraints have some mediating effects in the relationship between environmental regulation and enterprise innovation.

Table 5. Results of the regression after adding and controlling variables

Variables	Model (1) RDS	Model (2) FC	Model (3) RDS
ERI	0.123*** (3.724)	0.00234* (1.733)	0.120*** (3.629)
FC			1.386*** (2.996)
ROA	2.627*** (5.165)	0.118*** (5.681)	2.463*** (4.822)
LS1	-0.00478*** (-2.980)	-0.000554*** (-8.435)	-0.00401** (-2.474)
OPP	-0.0315* (-1.797)	-0.00460*** (-6.403)	-0.0251 (-1.425)
CF	0.650* (1.884)	-0.00926 (-0.655)	0.663* (1.923)
AGE	-0.0222*** (-5.896)	0.00529*** (34.30)	-0.0295*** (-6.583)
SIZE	0.695*** (27.98)	-0.0214*** (-21.05)	0.724*** (27.14)
L	-0.454*** (-2.927)	0.0147** (2.315)	-0.474*** (-3.060)
GROWTH	-0.161*** (-3.216)	-0.00607*** (-2.953)	-0.153*** (-3.048)
Constant	2.776*** (5.283)	1.772*** (82.33)	0.321 (0.330)
Observations	2,790	2,790	2,790
R-squared	0.351	0.380	0.353

Note: *** p < 0.01, ** p < 0.05, * p < 0.1; t value is given in parentheses.

Secondly, on the basis of the original model, the two control variables of investment opportunity (OPP) and cash flow (CF) are removed, and the regression results are shown in Table 6. It can be seen that there is still a significant

negative correlation between environmental regulation and enterprise innovation, and financing constraints have some mediating effects in the relationship between environmental regulation and enterprise innovation.

Table 6. Regression results after reducing and controlling variables

Variables	Model (1) RDS	Model (2) FC	Model (3) RDS
ERI	0.134*** (4.066)	0.00362*** (2.677)	0.128*** (3.908)
FC			1.445*** (3.147)
ROA	3.456*** (9.125)	0.0478*** (3.064)	3.387*** (8.942)
LS1	-0.00428*** (-2.688)	-0.000602*** (-9.169)	-0.00341** (-2.114)
AGE	-0.0225*** (-6.030)	0.00545*** (35.47)	-0.0303*** (-6.768)
SIZE	0.685*** (34.92)	-0.0171*** (-21.15)	0.710*** (33.63)
Constant	2.704*** (6.538)	1.673*** (98.10)	0.288 (0.330)
Observations	2,790	2,790	2,790
R-squared	0.345	0.366	0.347

Note: *** p < 0.01, ** p < 0.05, * p < 0.1; t value is given in parentheses.

The regression results of the two tests are basically consistent with the conclusion of the main part of this paper,

namely, the strengthening of environmental regulation has a significant inhibitory effect on enterprise innovation, and the financing constraint plays an intermediary role in this relationship. In summary, the model passed the robustness test.

6. Conclusion and Revelation

6.1. Research Conclusion

This paper selects the listed companies of heavy pollution manufacturing industry in Shanghai Stock Exchange and Shenzhen Stock Exchange from 2014 to 2018 as samples to establish OLS regression model to study the impact of environmental regulation on enterprise innovation, and explore the intermediary effect played by financing constraints. The results of the study indicate that, The intensity of environmental regulation has a significant inhibitory effect on the R & D and innovation of heavily polluting enterprises, When environmental regulation is strong, The input cost of environmental protection input for enterprises will increase, May lead to a shortage of disposable funds for enterprises, And then affect the enthusiasm of enterprises in innovation, The level of R & D investment will be reduced; Financing constraint plays an intermediary role in the relationship between environmental regulation and enterprise innovation, It shows that part of the inhibition of enterprise innovation by environmental regulation is achieved through financing constraints, The greater the intensity of environmental regulation, The higher the financing constraints will be, Thus, the enterprise R & D investment will be reduced.

6.2. Policy Proposal

6.2.1. Policy Recommendations for Local Governments:

Formulate a reasonable environmental regulation system. As shown in the results of this paper, for heavy polluting enterprises, when environmental regulation is too strong, the pressure from government policies on environmental pollution control makes the pollution control costs incurred by enterprises to avoid political costs squeeze the R & D investment to some extent and reduce the intensity of R & D investment. In order to encourage enterprise innovation, the government in environmental regulation policy at the same time, can provide guarantee for enterprise innovation, such as increasing funding for scientific research, environmental protection research and development activities for financial subsidies, etc., develop diversified types of environmental regulation, optimize environmental regulation measures, to ensure the intensity of the environmental regulation within a reasonable range, the incentive enterprises for environmental protection at the same time, encourage enterprises to continuously strengthen innovation, promote the development of green innovation.

Improve the financial market system. Local governments should actively promote the process of financial marketization, and improve the financial system by standardizing the financial system, strengthening investment and financing supervision, and establishing environmental protection financing mechanism, so as to create a good financial environment for enterprise innovation and strengthen the ability of enterprises to obtain financial resources. An environmental protection financing mechanism will be gradually established to provide sufficient financial support for enterprises' technological innovation. Simply relying on government regulation to promote enterprises to

pursue positive environmental behavior is still insufficient, requiring the support of financing mechanism. Financing is an important influence condition of enterprise technological innovation.

6.2.2. Suggestions for Enterprises:

Actively disclose environmental information. Due to the inevitable close connection between external financial support and enterprise innovation activities, enterprises should also start from their own perspective and strive to reduce the financing constraints they face. In addition to actively improving their own business and financial conditions, they should also take the initiative to disclose environmental information, and show the society and the public their attitude towards environmental responsibility and achievements in environmental protection, so as to fully attract external investors and improve their financing ability.

Make full use of innovation resources to improve the innovation ability of enterprises. Scientific research personnel is the premise for enterprises to innovate. Enterprises should increase the introduction of scientific research talents, improve the construction of scientific research talents team, strengthen the cooperation with major institutions of higher learning, provide a good platform for the development of scientific research talents, retain talents through equity incentive, and prevent the brain drain. When enterprise innovation can bring economic benefits to it, the willingness of enterprises to carry out environmental protection will also be strengthened, thus reducing environmental pollution. Therefore, enterprises should make full use of all kinds of innovation resources, improve their innovation ability, and promote the sustainable development of enterprises.

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