Research on the Influence of Environmental Regulation on Enterprise Technology Innovation Investment

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Abstract: In this paper, the panel data of A-share companies listed on Shanghai and Shenzhen Stock Exchanges from 2013 to 2021 are selected as the research sample, to empirically analyze the impact of environmental regulation on enterprise investment in technological innovation, and introduce government subsidies as the adjustment variable. The conclusion is as follows: Environmental regulation has a negative impact on the investment of enterprise technology innovation, and the government subsidy positively regulates the relationship between environmental regulation and the investment of enterprise technology innovation. Research will broaden the new ideas and research scope for the related research of promoting technological innovation by environmental policies, and provide theoretical support for realizing the win-win situation of ecological civilization construction and innovation-driven development.

Keywords: Environmental Regulation; Investment in Technological Innovation of Enterprises; Government Subsidy; Ownership Property

1. Introduction

In September 2020, China proposed the " dual-carbon target", which is to achieve the peak of carbon dioxide emissions by 2030 and carbon neutrality by 2060 at the 75th Session of the United Nations General Assembly. The State Council issued the " Opinions on Fully, Accurately and Comprehensively Implementing the New Development Concept and Doing a good job of Carbon Peak Carbon neutrality", which put forward the top-level policy framework of " 1+N", that is, decarbonization is an important part of environmental governance issues, and it is also the only way for China's economic and social transformation from extensive development to high-quality sustainable development.

2. The Impact of Environmental Regulation on Firms' Technological Innovation Input

When enterprises pursue profit in production and operation, they cause negative externalities to the environment and increase social costs. Based on this, governments of all countries have formulated environmental protection policies to regulate the environmental pollution behavior of enterprises in production activities. In the early stage of the implementation of environmental regulation policies, most of the policies were mandatory, which not only regulated the behavior of enterprises, but also discouraged enterprises' enthusiasm for technological innovation to a large extent. Since the environmental regulation policy was put forward, scholars have launched a fierce discussion and study on a series of economic problems that may be caused by it. "Porter hypothesis" in the academic circle, which proposes that environmental regulation has a U-shaped relationship with technological innovation input, which is first to inhibit and then to promote. It holds that environmental protection policies have an impact on the economy mainly through promoting enterprises' investment in technological innovation or adopting innovative technologies, which may increase costs in the short term, but can improve enterprises' production efficiency in the long run. Increase the competitiveness of enterprises and promote economic growth.

3. Theoretical Analysis and Research Hypothesis

3.1 The Impact of Environmental Regulation on Firms' Technological Innovation Input

In order to correct the negative externalities of environmental pollution of enterprises and internalize the cost of environmental governance, enterprises have to increase their investment in environmental governance or impose penalties for violating environmental regulatory policies, so as to reduce their internal innovation investment and R&D expenditure. The crowding out effect refers to the decrease of private consumption caused by the increase of government expenditure, and environmental regulation is the crowding out effect of technological innovation input of enterprises. According to Jaffe (1995) 's research on the relationship between environmental regulation and corporate performance, environmental regulation can inhibit the improvement of corporate performance. In the process of seeking transformation, enterprises will face huge financial pressure. Part of the funds of enterprises must be invested in environmental governance instead of R&D and innovation, and the growth of enterprise performance will be affected. This is a vicious circle.

Based on the above analysis, the following hypothesis is proposed:

H1: Environmental regulation has a negative impact on firms' technological innovation input

3.2 The moderating effect of government subsidies on the influence mechanism of environmental regulation on firms' technological innovation input

Government subsidies will have a moderating effect on the impact of environmental regulation and firms' technological innovation input. Government subsidies may have an impact on enterprises' technological innovation input from three aspects: resource allocation, benefit driving and industry competition.First of all, in terms of resource allocation efficiency, high government subsidies can reduce the economic risks faced by enterprises, so that enterprises choose to rely on government subsidies to conduct business activities, rather than rely on improving technological innovation ability to improve competitiveness. Companies may be inclined to devote more resources to meeting environmental regulatory requirements than to technological innovation. Secondly, in terms of interest driving, government subsidies are often accompanied by some terms and restrictions, including the relevant requirements of environmental regulations. Enterprises may regard environmental regulation as a compulsory obligation and take corresponding measures only to meet the requirements of regulations, rather than out of independent technological innovation and environmental protection awareness. The interest drive may reduce the enthusiasm of enterprises to invest in technological innovation. Finally, it will reduce the competition among enterprises. High government subsidies may lead to a decrease in the degree of competition among enterprises in the market. When enterprises receive subsidies, they may no longer face the pressure of competition with other enterprises, so they may stay in a corner and have less motivation to carry out technological innovation. The lack of competition incentive may reduce the investment of enterprises in technological innovation. Therefore, government subsidies can positively regulate the negative impact of environmental regulations on firms' innovation input.Liu Jing (2019) believed that when the degree of environmental uncertainty was high, government subsidies mainly showed crowding out effect on R&D investment. Wang Yihui (2013), based on the panel data of high-tech enterprises in China, found that the innovation performance of enterprises receiving government subsidies was worse.

H2: Government subsidies positively regulate the relationship between environmental regulation and technological innovation input of enterprises

4. Research Design

4.1 Sample Selection and Data Source

In this paper, the panel data of A-share companies listed on Shanghai and Shenzhen Stock exchanges from 2013 to 2021 is used as the research sample for empirical analysis, and the following processing is carried out: (1) Enterprises with ST

beginning are excluded; (2) Screening samples with missing data; (3) Tail reduction processing, to control the influence of extreme values, to ensure the integrity of data and the scientificity of empirical results, finally selected 2,781 enterprises as observation data.

4.2 Variable Definition

4.2.1 Explained Variable

Enterprise innovation investment intensity (TI) : The existing research literature is mainly measured from the perspective of relative index and absolute index. Relative indicators generally refer to the ratio of R&D investment in the current year to the operating income of the year and the ratio of R&D investment to the total assets of the enterprise. Absolute index refers to the amount of R&D investment of an enterprise in a certain accounting period, or on this basis, the logarithmic treatment of enterprise R&D investment (Feng Zhaoyang 2020). This paper believes that the amount of R&D investment is related to the operation status of enterprises, so this paper chooses the relative index of enterprises' R&D investment to study, and uses R&D investment/main business income to measure the level of enterprises' R&D investment.

Environmental Regulation Intensity (ER) : Since there is no unified measurement standard for the intensity of environmental regulations in the academic community, and environmental regulations are abstract and difficult to measure directly, this paper uses Zhang Cheng (2011) and Shen Neng (2012) as reference to measure the investment amount of industrial pollution control, and divides the operating cost of industrial wastewater, waste gas and solid waste treatment facilities in each province and city by the total industrial output value.

4.2.2 Regulating Variable

Government subsidy (Sub) : There are two common ways to measure government subsidy: one is to adopt absolute index and take logarithmic measure of government subsidy received by enterprises (Bai Junhong, 2011) and Yang Yang, 2015). The other is to adopt relative indicators, such as the ratio of government subsidies to the government subsidies of the previous year or the total assets of enterprises or the business income of enterprises (Kong Dongmin, 2013). In this paper, absolute indicators are used to measure the logarithm of government subsidies.

4.2.3 Control Variable

Company Size: Enterprise size is an important factor affecting innovation investment. Generally speaking, the larger the scale of the enterprise, the greater the intensity of technological innovation investment, and vice versa. This paper chooses the method of logarithm of total assets of enterprises to measure.

Corporate financial leverage (DFL) : Generally speaking, the greater the financial leverage, the lower the intensity of technological innovation investment under the pressure of debt repayment, and vice versa. This article uses EBIT/gross EBIT to measure.

Operating leverage (DOL) : Generally speaking, the lower the fixed asset ratio, the less idle capital, the less innovation investment, and vice versa. In this paper, the rate of change of EBIT/rate of change of production and sales volume is used to reflect the capital status of enterprises.

Growth: The growth capacity of an enterprise is calculated using the growth rate of operating revenue. Because faster-growing firms are likely to require more investment in innovation; The faster the company grows, the higher the return of capital invested by the company, and the more funds available for research and development. Therefore, it will affect the innovation input of enterprises.

Ownership concentration (OC) : The greater the number of shares held by shareholders, the greater the right to make decisions on major matters, and the controlling shareholders have a significant impact on the company's strategic decisions. Therefore, the concentration of equity will directly or indirectly affect the innovation input of enterprises. This study draws on the studies of Chen Deping (2011) and Yan Aimin (2013), and uses the shareholding ratio of top ten shareholders to measure the ownership concentration.

Equity nature (State) : The equity nature of an enterprise may structurally affect the innovation motivation of an

enterprise, so it needs to be controlled. In this paper, the value of state-owned enterprise is 1, and that of non-state-owned enterprise is 0.

The specific definitions of variables are shown in Table 1.

Table 1 Variable description table

type	name	Symbol definition and calculation method	Symbol definition and calculation method
Explained variable	Technological innovation input intensity	TI	R&d investment/Main business income
Explanatory variable	Environmental regulation intensity	ER	The ratio of the operating cost of industrial wastewater, waste gas and solid waste treatment facilities to the total industrial output value of each province and city
Regulating variable	Government subsidy	Sub	The logarithm of the government subsidy
Control variable	Company size	Size	Ln (Total assets +1)
	Financial leverage	DFL	Total liabilities/total assets
	Operating leverage	DOL	Total fixed assets/total assets
	growth	Growth	(Operating income at the end of the current period - Operating income at the end of the previous period)/ Operating income at the end of the previous period
	Ownership concentration	OC	Share of top 10 shareholders
	Equity nature	State	State-owned enterprises 1, non-state-owned enterprises 0

4.3 Model Setting

In order to verify the above hypothesis, Model 1 and Model 2 are constructed respectively for analysis in order to test the impact of environmental regulation and enterprise technological innovation input and the regulatory effect of government subsidies on the impact of environmental regulation on enterprise technological innovation by referring to the methods of existing literature and combining with the theoretical analysis previously presented in this paper:

$$TI_{it} = \beta_0 + \beta_1 ER_{it} + \beta_2 Size_{it} + \beta_3 DFL_{it} + \beta_4 DOL_{it} + \beta_5 Growth_{it} + \beta_6 OC + \beta_7 State + \varepsilon_{it} \quad (1)$$

$$TI_{it} = \beta_0 + \beta_1 ER_{it} + \beta_2 Sub_{it} + \beta_3 ER_{it} \times Sub_{it} + \beta_4 Size_{it} + \beta_5 DFL_{it} + \beta_6 DOL_{it} + \beta_7 Growth_{it} + \beta_8 OC + \beta_9 State + \varepsilon_{it} \quad (2)$$

β_0 is the constant term; β_n is the coefficient of each variable; TI invests in technological innovation; ER is environmental regulation; Sub is government subsidy; ER×Sub is an interactive term used to measure the moderating effect of government subsidies. The rest are control variables; $\varepsilon_{it}$is a random disturbance term.

5. Empirical Analysis

5.1 Descriptive Statistical Analysis

Table 2 shows the descriptive statistical analysis of the main variables. First, the mean value and standard deviation of technological innovation input (TI) of enterprises are both 0.032, and the difference between the minimum value and the maximum value is 0.149, indicating that the intensity of R&D input of different enterprises is somewhat different. Secondly, the statistical data of environmental regulation (ER) shows that the mean, median and standard deviation are all 0.002, with a

small standard deviation, indicating that the overall level of environmental regulation at this stage is relatively low, and the gap between environmental regulations imposed on different enterprises is small. There is a large difference between the extreme values of the government subsidy (Sub) of the regulating variable. The average value of the government subsidy is 15.247, and the standard deviation is 3.933. The overall support of the government to the sample enterprises is relatively strong, but there is a certain gap between the government subsidies of different enterprises.

Table 2 Descriptive statistical analysis

variable	Observed value	Mean value	median	Standard deviation	Minimum value	Maximum value
TI	2,781.000	0.032	0.026	0.032	0.000	0.149
ER	2,781.000	0.002	0.002	0.002	0.000	0.008
Sub	2,781.000	15.247	16.096	3.933	0.000	20.112
Size	2,781.000	18.878	22.718	9.155	0.000	26.806
DFL	2,781.000	1.739	1.119	1.871	0.302	11.381
DOL	2,781.000	1.157	1.000	0.490	0.938	3.699
Growth	2,781.000	0.107	0.022	0.692	-0.888	3.655
OC	2,781.000	55.504	54.830	16.098	24.150	88.810

5.2 Correlation Analysis

In order to avoid the existence of multicollinearity among the variables which may affect the results of empirical analysis, the correlation analysis of the selected variables is carried out. The results are shown in Table 3: We can see from the positive and negative degree of correlation coefficient and significance that both explanatory variable environmental regulation (ER) and regulating variable government subsidy (Sub) are significantly negatively correlated with explained variable technological innovation input (TI), and explanatory variable environmental regulation (ER) passes the significance level test of 1%, which preliminarily verifies hypothesis 1. Among the control variables, firm Size (Size) and operating leverage (DOL) are positively correlated with technological innovation input (TI), while the remaining three variables are negatively correlated, and the financial leverage (DFL) and ownership concentration (OC) are both significant at the level of 1%. At the same time, the correlation coefficients between the main variables were all less than 0.6, indicating that there was no significant multicollinearity problem. Follow-up studies can be conducted based on this data.

Table 3 Correlation analysis

	TI	ER	Sub	Size	DFL	DOL	Growth	OC
TI	1.000							
ER	-0.114***	1.000						
Sub	-0.042**	0.171***	1.000					
Size	0.069***	-0.124***	0.068***	1.000				
DFL	-0.065***	0.033*	0.021	0.018	1.000			
DOL	0.005	0.048**	0.021	-0.028	0.420***	1.000		
Growth	-0.032*	-0.024	-0.039**	-0.010	-0.028	-0.012	1.000	
OC	-0.123***	0.010	0.127***	0.051***	-0.088***	-0.052***	-0.045**	1.000

Note: *** p<0.01, ** p<0.05, * p<0.1，, the same below

5.3 Regression Analysis

5.3.1 Reference Regression

According to the analysis of the benchmark regression results in Table 4 (1), the environmental regulation coefficient is -1.194, which passes the significance level test of 5%, and environmental regulation has a negative impact on innovation

input. The more environmental regulations are required, the lower the intensity of technological innovation input of enterprises. Hypothesis 1 is verified that environmental regulations have a negative impact on firms' technological innovation input. The reason may be that in order to meet the requirements of environmental regulations, enterprises have to use the excess operating profits to complete the relevant indicators of environmental requirements, thus reducing the funds for technological innovation. In order to maintain normal operations, the investment in technological innovation of enterprises has to be reduced accordingly. Among the control variables, company Size (Size) and ownership concentration (OC) both have a negative impact on technological innovation input at the significance level of 1%.

5.3.2 Regulatory Effect Analysis

After adding adjustment variables and interaction items, the results are shown in the columns of Table 4 (3) : After the introduction of the interaction term, the regression coefficient of environmental regulation (ER) is -1.112, which passes the significance level test of 1%, and the interaction term coefficient is -0.130, which is significant at the 5% level, consistent with the direction of the baseline regression, indicating that government subsidies have a positive moderating effect on the impact of environmental regulation on enterprise innovation input. Hypothesis 2 is verified. Companies may rely more on government subsidies than their own technological innovation capabilities to improve competitiveness, and devote more resources to meeting regulatory requirements than to technology research and development and innovation. At the same time, enterprises may regard environmental regulations as compulsory obligations only to meet the requirements of laws and regulations rather than out of independent technological innovation and environmental protection awareness, which may reduce the enthusiasm of enterprises in technological innovation investment. Moreover, after receiving subsidies, enterprises may no longer face the pressure of competition with other enterprises, thus reducing the motivation of technological innovation and investment in it.

Table 4 Regression analysis

	(1)	(2)	(3)
VARIABLES	TI	TI	TI
ER	-1.194**	-1.232***	-1.112***
	(-2.27)	(-5.48)	(-4.84)
Sub		-0.000***	-0.000***
		(-4.23)	(-4.83)
ER*Sub			-0.130**
			(-2.42)
Size	-0.013***	-0.003***	-0.003***
	(-6.29)	(-3.56)	(-3.41)
DFL	-0.000	-0.000	-0.000
	(-0.03)	(-1.12)	(-1.13)
DOL	-0.000	0.000	0.000
	(-0.09)	(0.73)	(0.82)
Growth	0.000	-0.000**	-0.000*
	(0.11)	(-2.07)	(-1.94)
OC	-0.000***	-0.000	-0.000*
	(-3.57)	(-1.64)	(-1.74)
Constant	0.303***	0.096***	0.095***
	(8.11)	(6.86)	(6.83)
N	2,781	2,781	2,781
R-squared	0.027	0.033	0.035

5.4 Robustness Test

This paper uses the method of changing the sample interval to conduct robustness test. Since 2020 and 2021 are greatly affected by the epidemic, the data of 2020 and 2021 are screened for regression. As shown in Table 5 (1), it can be seen that environmental regulation (ER) still has a negative impact on technological innovation input (TI) at 1% significance level. It can be seen from Table 5 (2) that the interaction term (ER*Sub) is -0.119, which is significant at the significance level of 10% and consistent with the direction of environmental regulation (ER) in the baseline regression, indicating that government subsidies still positively regulate the relationship between environmental regulation (ER) and enterprise technological innovation input (TI), which is consistent with the conclusions above. It shows that the results of this paper are robust.

Table 5 Robustness test

	(1)	(2)
VARIABLES	TI	TI
ER	-0.795***	-0.451
	(-3.05)	(-1.63)
Sub		-0.000***
		(-3.75)
ER*Sub		-0.119*
		(-1.74)
Size	-0.002**	-0.002**
	(-2.32)	(-2.44)
DFL	-0.000	-0.000
	(-0.45)	(-0.41)
DOL	0.000	0.001
	(0.91)	(1.17)
Growth	-0.000	-0.000
	(-1.00)	(-0.97)
OC	-0.000*	-0.000*
	(-1.72)	(-1.69)
Constant	0.079***	0.087***
	(4.72)	(5.15)
N	2,163	2,163
R-squared	0.012	0.021

5.5 Heterogeneity Test

Since state-owned enterprises may have stricter supervision and restrictions on the use of government subsidy funds, which cannot be increased or decreased at will, and state-owned enterprises may have certain requirements on environmental regulations, environmental regulations have little impact on technological innovation investment of state-owned enterprises. In contrast, non-state-owned enterprises may have less supervision, and if the environmental regulation is very strong, the enterprises may be forced to increase the fine expenditure. Therefore, the enterprises may be forced to increase the investment in technological innovation and improve the environmental protection level to meet the requirements of environmental regulation. Therefore, this paper divides state-owned enterprises and non-state-owned enterprises according to the nature of equity ownership and conducts heterogeneity test. In the heterogeneity test, all enterprises are divided according to equity nature, and non-state-owned enterprises are assigned 0 and state-owned enterprises are assigned 1. The

analysis results are shown in Table 6. In non-state-owned enterprises, environmental regulation has a significant negative impact on innovation input, with a significance level of 1%, while the environmental regulation coefficient of state-owned enterprises is not significant, and the impact of non-state-owned enterprises' environmental regulation on technological innovation is more obvious.

Table 6 Heterogeneity analysis

VARIABLES	(1) Non-state-owned enterprise	(2) State-owned enterprise
ER	-3.015***	-0.883
	(-3.24)	(-1.44)
Size	0.000	0.000***
	(0.30)	(2.70)
DFL	-0.000	-0.000
	(-0.17)	(-0.86)
DOL	0.002	0.000
	(1.06)	(0.00)
Growth	-0.001	-0.000
	(-1.49)	(-0.41)
OC	0.000	-0.001***
	(0.01)	(-6.88)
Constant	0.041***	0.059***
	(4.60)	(11.26)
N	508	2,273
R-squared	0.028	0.024

6. Research Conclusion and Suggestion

6.1 Research Conclusion

First, environmental regulation has a negative impact on firms' technological innovation input.企 In order to meet the prescribed standards of legal policies, enterprises have to increase investment in environmental governance to minimize the impact of pollution emissions on the environment, and the survival cost of enterprises is forced to increase, thus reducing the profits of enterprises. When the profits are reduced, the innovation investment of enterprises will decrease accordingly. Therefore, enterprise innovation technology research and development is slow.

Second, by analyzing the moderating effect of government subsidies on the impact of environmental regulation on enterprise technological innovation, it can be shown that government subsidies positively regulate the relationship between environmental regulation and enterprise technological innovation. Enterprises will gradually rely on government subsidies and choose to give up investment in enterprise innovation and technology development..

Third, from the heterogeneity analysis of enterprise equity, the negative impact of environmental regulation on enterprise technological innovation is more significant in non-state-owned enterprises.

6.2 Policy Suggestion

Based on the above analysis conclusions, in order to further improve the level of technological innovation investment of enterprises, the following policy suggestions are proposed:

First, assess and improve the role of environmental regulation, and conduct multi-party research and field visits to determine the appropriate intensity of environmental regulation, and promote the synergistic development of environmental

regulation and enterprise technological innovation to the greatest extent.

Second, according to the conclusion of this paper, environmental regulation has a negative impact on technological innovation of enterprises. Therefore, in order to avoid being subject to environmental regulation, enterprises can consider adjusting their innovation and upgrading cycle to adapt to the phased goals of environmental regulation.

Third, enterprises themselves should pay more attention to the investment in technological innovation, not only pay attention to the profitability at the present stage, but also look at the innovation problem from the perspective of development, make more reasonable use of government subsidies, improve the production and operation efficiency of enterprises and meet the relevant requirements of environmental regulations.

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