

Research on the Relationship between Informal Environmental Regulation and Innovation Efficiency against the Background of Government Support

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Abstract Using the micro-level data of 104 listed companies in manufacturing industry during 2011-2016, this paper examines how informal environmental regulation effects on enterprises' innovation efficiency under the different government support ways including government direct subsidy and tax incentives. The results show that: (1) the empirical results of the whole sample show that the relation between public attention and the efficiency of enterprise innovation show "U" type, and the media attention has a significant negative effect with enterprise innovation efficiency; (2) If the type of listed companies in the manufacturing industry is pollution - intensive, the public attention has a significant negative impact with the efficiency of enterprise innovation, and the relationship between media attention and enterprise innovation efficiency is not significant; (3) If the type of listed companies in the manufacturing industry is clean, the relationship between informal environmental regulation and enterprise innovation efficiency is not significant. However, when the government direct subsidy is high, there is a significant positive correlation between public concern and enterprise innovation efficiency.

Key words government innovation support; informal environmental regulation; tax incentives; innovation efficiency

1. Introduction

Since the reform and opening up, China has made remarkable achievements in economic development. However, the "Report on Environmental Performance Index 2016" released by Yale University in the United States shows that China's air quality is the second lowest in the world, only slightly stronger than that of Bangladesh. Faced with the rapid economic development and worsening of environmental quality, our government has successively set forth the development goals of "green development" and "prosperity, strong democracy and civilized harmony and beauty," and has promoted the transformation of the mode of economic development from high-speed growth to high-quality development in an attempt to achieve economic development Win-win situation with environmental protection. At the same time, with the people's growing need for a better life, the increasing public awareness of environmental protection, and the popularization of multimedia and Internet technologies, the number of media reports and public opinions of various pollution incidents has been increased. The media and the public are increasingly paying attention to the issue of ecological environment, which virtually creates an "informal" environmental regulation that affects both the government and the sewer enterprises in an ever-increasing scale, which promote the relevant government departments to quickly start the project investigation, information disclosure and treatment measures.

Moreover, some studies have found that the effect of formal environmental regulation is not satisfactory. For example, environmental laws and regulations are too rigid. Local governments neglect the implementation of environmental laws and regulations and the environmental laws and regulations are still not perfect. This has led to the lack of innovative motivation, inefficient environmental regulation and some enterprises rent-seeking space ^{[1] [2] [3]}. Informal environmental regulation can make up for the government failure and reduce the cost of government environmental management. However, informal environmental regulation can both improve the efficiency of the government's environmental regulation ^[4] and may also have a negative impact ^[5]. Considering that the innovation driven under the new economic normal requires enterprises to seek ways to reduce the cost of environmental governance and promote the innovation efficiency of enterprises under the circumstances that the intensity of informal environmental regulation is enhanced, we can better solve the problem that the informal environmental regulation restricts the innovation efficiency of enterprises if getting the government's innovative support at the moment. Therefore, it is of great theoretical and practical significance to combine informal environmental regulation and government

innovation support to explore its impact on the efficiency of enterprise innovation. Based on the existing related literature, based on institutional theory and legitimacy theory, this paper builds a comprehensive effect model of informal environmental regulation, government innovation support and enterprise innovation efficiency, and uses the data of China's manufacturing listed companies from 2011 to 2016 to analyze whether the increase of government innovation support can promote the influence of informal environmental regulation on the efficiency of enterprise innovation.

2 Theoretical Analysis

2.1 informal environmental regulation and enterprise innovation efficiency

Legitimacy theory holds that a firm exists in a social network and its behavior and decision-making will be affected by the various stakeholders in its social network. The firm will only exist if the society considers it is legitimate. Now people pay more and more attention to environmental protection. The unsatisfactory result of government regulation has aroused the contradiction between the public and the polluting enterprises. People have to increase the resource prices of polluting factories in order to improve the quality of life. Manufacturers are expected to raise the penalty in disguise and to reduce resource requirements through green innovation.

A few scholars have conducted empirical research on the impact of informal environmental regulation on business innovation. Shimshack use social credibility to measure informal environmental regulation, and found that informal environmental regulation actively monitors and controls the pollution of enterprises^[6]. Based on the legitimacy theory, Walden and Mao Jiahua found that external public pressure will force enterprises to disclose environmental information and they will influence the stakeholders' understanding of environmental performance through technological upgrading^{[7][8]}. Li Xin regards cyberpublic opinion as a measure of the degree of informal environmental regulation and finds that informal environmental regulation helps to mitigate smog pollution^[9]. Zhang Tongbin thinks that the participation of the public will have an impact on the innovation behavior of enterprises. However, with the increasing public awareness of environmental protection, due to the lack of environmental rights of information, litigation and compensation, it is more likely to cause public over-reaction to environmental pollution and even serious mass incidents, which is finally conducive to the normal operation of enterprises and innovative behavior^[10].

2.2 Government Innovation Support and Enterprise Innovation Efficiency

Innovation is an effective way to improve the environmental quality. However, innovation is a high-risk activity. Some enterprises lack the capital and strength, and are incapable of assuming the corresponding risks and corresponding technological innovations^[11]. Keynes said in his masterpieces "Employment, The General Theory of Interest and Money" emphasizes that the government should extend "visible hand" intervention in the market to make up for the market failure and promote the efficient allocation of resources^{[12][13]}. Technology innovation theory and basic theory of resources hold that the government can reduce the uncertainty and cost of innovation through the appropriate R & D subsidies, tax incentives and policy incentives, and thus promote R & D investment and innovation. Guellec and Zhang Tongbin also confirmed this view^{[14][15]} through an empirical research. From the perspective of signal theory, scholars such as Kleer and Guo Xiaodan think that government innovation support will release favorable signals to the outside world and help enterprises affix the labels recognized by the government. This not only achieves government innovation support but also gives them more opportunities to obtain support from other channels, Which in turn helps enterprises to obtain the necessary innovation resources to enhance innovation performance^{[16][17]}.

2.3 The interaction between informal environmental regulation and government innovation support

In the economic transition period of China, informal environmental regulation and government innovation support can significantly affect the innovation behavior of enterprises and their performance. Moreover, the market mechanism in China is not perfect enough at present. The government can effectively reduce the costs and uncertainties brought by informal environmental regulation to the innovation of enterprises and gain some positive signals from enterprises by providing innovative support, which can enhance the innovation power of enterprises^[17]. At the same time, in order to gain recognition from the public as well as from the media, the enterprises will try their best to meet the public's needs, including improving the quality of the environment that is most concerned by the general public and improving the production process so as to achieve a win-win result of environmental and economic benefits.

If we increase government innovation support, we can better solve the restriction of informal

environmental regulation on enterprise innovation. That is to say, in the situation of tighter informal environmental regulation, in order to promote the innovation behavior of enterprises, it is necessary to increase government innovation support accordingly. Sun Wei used 35 industries panel data, and found that the relationship between formal environmental regulation and enterprise innovation shows a "U" type, and formal environmental regulation can significantly promote business innovation if increasing government investment^[18].

3 Research Design

3.1 sample selection and data source

The sample selection process and data sources are as follows: Based on a detailed analysis of manufacturing listed companies in 2011-2016, excluding ST and data serious lack of data, as well as the apparent existence abnormal data. Therefore, left the 104 manufacturing companies. The financial data is obtained through flush database, while the patent number is obtained through manual search by soopat patent search website. The enterprise sewage charges are collected manually through the website of Environmental Protection Bureau. The annual industrial output value of each region is mainly obtained through China Industrial Statistical Yearbook, and public attention and media attention data are obtained through manual search by Baidu search engine. Data such as government innovation support and control variables are obtained from Flush database. For individual missing Data, the data is collected manually from the annual report of the business.

3.2 model building

Based on the theoretical basis and empirical hypothesis analysis of the above literature studies, the following model is established to analyze the role of government innovation support, informal environmental regulation and the efficiency of enterprise innovation in China's manufacturing industry as the research object. In order to minimize the multicollinearity between the heteroscedasticity of the equation and variables, the logarithm of the direct government subsidy, government tax relief and the number of news reports in the model is logarithmic. Considering that the influence of public attention on the efficiency of enterprise innovation can be expressed in a non-linear way^[14], therefore, the model introduces the square item of social public concern:

$$ie_{it} = \alpha_1 + \beta_{11}irpi_{it} + \beta_{12}\ln(gds_{it}) + \beta_{13}\ln(gtp_{it}) + control + \varepsilon_{1it} \quad (1)$$

$$ie_{it} = \alpha_2 + \beta_{21}irpi_{it} + \beta_{22}irpi_{it}^2 + \beta_{23}\ln(gds_{it}) + \beta_{24}\ln(gtp_{it}) + control + \varepsilon_{2it} \quad (2)$$

In the formula, i indicates the enterprise, t said time, ie said the efficiency of enterprise innovation, $irpi$ said the formal intensity of environmental regulation, gds is the strength of direct financial subsidies provided by the government prior to R & D, gtp is the tax incentives intensity provided by the government for enterprise innovation, $control$ is the control variable, ε is random disturbance, α is a constant term, β is the estimated coefficient of each variable.

Next, test the influence of media attention on the efficiency of enterprise innovation and establish the following model:

$$ie_{it} = \alpha_5 + \beta_{51}\ln(irpo_{it}) + \beta_{52}\ln(gds_{it}) + \beta_{53}\ln(gtp_{it}) + control + \varepsilon_{5it} \quad (3)$$

Finally, to test whether differences in the intensity of government innovation support can affect the relationship between the intensity of informal environmental regulation and the efficiency of firm innovation. Therefore, we introduce the product of the intensity of informal environmental regulation and government innovation support in models (4) (5) (6) (7), where the product of social public attention and government direct financial subsidy intensity is expressed as $irpi \times gds$, the product of the social public attention and the government tax incentives is expressed as $irpi \times gtp$, the product of the media attention and the government direct financial subsidies intensity is expressed as $irpo \times gds$, the product of media attention and tax incentives intensity is expressed as $irpo \times gtp$, the corresponding measurement model is as follows:

$$ie_{it} = \alpha_3 + \beta_{31}irpi_{it} + \beta_{32}irpi_{it}^2 + \beta_{33}\ln(gds_{it}) + \beta_{34}\ln(gtp_{it}) + \beta_{35}irpi_{it} \times \ln(gds_{it}) + control + \varepsilon_{3it} \quad (4)$$

$$ie_{it} = \alpha_4 + \beta_{41}irpi_{it} + \beta_{42}irpi_{it}^2 + \beta_{43}\ln(gds_{it}) + \beta_{44}\ln(gtp_{it}) + \beta_{45}irpi_{it} \times \ln(gtp_{it}) + control + \varepsilon_{4it} \quad (5)$$

$$ie_{it} = \alpha_6 + \beta_{61}\ln(irpo_{it}) + \beta_{62}\ln(gds_{it}) + \beta_{63}\ln(gtp_{it}) + \beta_{64}\ln(irpo_{it}) \times \ln(gds_{it}) + control + \varepsilon_{6it} \quad (6)$$

$$ie_{it} = \alpha_7 + \beta_{71}\ln(irpo_{it}) + \beta_{72}\ln(gds_{it}) + \beta_{73}\ln(gtp_{it}) + \beta_{74}\ln(irpo_{it}) \times \ln(gtp_{it}) + control + \varepsilon_{7it} \quad (7)$$

Which $irpo$ shows the media attention.

3.3 variable description

Innovative Efficiency: The frontier production function method is suitable for panel data analysis without the need to make a priori assumptions on the structure of the production function, allowing for the existence of inefficient behavior, eliminating the need to estimate the parameters and to disaggregate the variability, and therefore, Using it to estimate and analyze total factor productivity changes. Among them, human capital, net fixed assets and R & D investment are input variables, and patent and operating income are used as output variables. The innovation efficiency of enterprises needs a high level of R & D personnel and the innovation efficiency of enterprises is the embodiment of the creative achievements of core technicians. The higher the level of enterprise wages, the higher the human capital of enterprises. Therefore, employers should pay wages as an alternative measure. The number of patent applications is replaced by the average number of patent applications for three consecutive years.

Informal Environmental Regulation Intensity: This paper draws on the practice of Xu Yuan ^[19] and mainly constructs two indicators.

(1) attention of corporate Internet users

Public awareness of environmental issues on the Internet."environmental pollution" as the key word for Baidu index search, and regional classification, you can get the index value of all provinces. In order to transform regional data into firm data, refer to Cole et al. ^[20] $IRPI_{it} = \sum (S_{it} * IRPIV_{it})$ Where: i 、 r 、 t Represents enterprises, regions and years respectively; S Represents the proportion of i enterprises in the total industrial output value in the r region; $IRPIV$ Represents the public's attention to environmental pollution in region r .

(2) corporate media attention

Open media coverage of environmental pollution news."environmental pollution" and "business names" as keywords to search in Baidu news, according to different years, the news source is limited to a number of professional news sites, and then the search results obtained by screening, to retain the news on the actual pollution problems, Statistics.

Government direct subsidy intensity: Before the R & D activities, the intensity of government support for innovation is measured by the direct government subsidies.

Government tax incentives intensity: In order to encourage enterprises to improve their production processes and processes to improve the quality of their environment, some tax benefits will be given to enterprise innovation, measured by the tax rebates received by enterprises.

Firm Size: The effect of government technology funding to encourage enterprises to invest in research and development will be affected by the size of the enterprise, using the total assets of the enterprise to measure the firm size.

Enterprise Profitability: The profitability of a company directly determines the available capital of the enterprise, which will have some impact on the innovation of the enterprise. It is measured by the ratio of the total profit of the enterprise to the operating income.

Enterprise Age:the company is older, the more competitive it is, the more impact the experience accumulated on the total factor productivity over the operating life, and the more production and sales experience Can improve the overall operational efficiency of enterprises.

Enterprise debt-to-asset ratio: The debt-to-asset ratio reflects the financing status of an enterprise. The financing status directly affects the operation and production capacity of an enterprise.

Table 1 Variable Symbols and Measurement Methods

Variable type	Variable sign	Variable Description	Measurement method
Dependent variable	ie	Enterprise innovation efficiency	Enterprise total factor productivity
Independent variables	irpr	Public attention	The product of the average annual search volume of key words "environmental pollution" and enterprises accounted for the proportion of regional operating income ratio
	irpo	Media reports on corporate environmental pollution	The media coverage of enterprises on environmental pollution in the amount of news in Baidu engine

Table 1, cont.

	<i>gds</i>	The intensity of the government direct financial subsidies	Financial subsidies provided by the government prior to R & D
	<i>gtp</i>	The intensity of government tax incentives	the tax return that the business received
	<i>er × gds</i>	Interaction effect	Product term
	<i>er × gtp</i>	Interaction effect	Product term
	<i>irpr × gds</i>	Interaction effect	Product term
	<i>irpr × gtp</i>	Interaction effect	Product term
	<i>irpo × gds</i>	Interaction effect	Product term
	<i>irpo × gtp</i>	Interaction effect	Product term
	<i>age</i>	Business age	Years of establishment of the enterprise
	<i>alr</i>	Enterprise asset-liability ratio	Total corporate assets to total corporate debt ratio
	<i>pro</i>	Corporate profitability	Enterprise total profit and operating income ratio
	<i>size</i>	Enterprise size	Total assets of the enterprise

4 Empirical analysis

4.1 Descriptive statistical analysis

Here, the data features of each variable index, including the minimum value, the maximum value, the mean value and the standard deviation, are described in detail. The specific results are shown in Table 2.

Table 2 Variable Description Statistics

index	minimum value	maximum value	mean value	standard deviation
<i>ie</i>	0.251	48.443	1.078	2.102
<i>irpi</i>	0	3.502	0.249	0.485
<i>irpi</i> ²	0	12.262	0.297	1.231
<i>irpo</i>	0	117.000	8.302	16.169
<i>gds</i>	0.012	200.177	6.366	14.570
<i>gtp</i>	0	38.200	3.478	6.600
<i>size</i>	0.410	102.988	11.588	16.830
<i>age</i>	5.000	33.000	16.154	4.262
<i>alr</i>	0.060	0.979	0.506	0.197
<i>pro</i>	-0.715	0.707	0.059	0.131

4.2 Regression Analysis

4.2.1 Analysis of the impact of the entire sample

The panel data model selection and regression results based on all the samples of China's manufacturing listed companies are shown in Table 4. The results of redundancy test and Hausman test show that the models (1) to (7) support the following effects.

Table 3 The Impact on Environmental Regulation、Government Innovation Support and Enterprise Innovation Efficiency

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
<i>irpi</i>	-0.039	-0.562*		-0.609*	-0.575*		
<i>irpi</i> ²		0.433*		0.459**	0.420*		
<i>irpo</i>			-0.324*			-0.355*	-0.328*
<i>gds</i>	-0.020	-0.029	-0.018	-0.035	-0.037	-0.031	-0.026
<i>gtp</i>	0.215***	0.203**	0.200**	0.207**	0.200**	0.193**	0.183*
<i>size</i>	-0.254	-0.428*	-0.231	-0.441*	-0.417	-0.210	-0.226

Table 3, cont.

age	0.150	0.213	0.220	0.206	0.212	0.230	0.201
alr	-0.423***	-0.396***	-0.409***	-0.398***	-0.396***	-0.410***	-0.412***
pro	-0.193**	-0.171*	-0.166*	-0.183*	-0.172*		-0.192*
irpi \times gds				0.026			
irpi \times gtp					0.112		
irpo \times gds						0.180*	
irpo \times gtp							0.175*
Redundancy test	1.169 (0.147)	1.207 (0.104)	1.155 (0.167)	1.214 (0.098)	1.198 (0.104)	1.170 (0.106)	1.212 (0.098)
Hausman test	14.529 (0.043)	19.633 (0.012)	18.112 (0.012)	21.445 (0.011)	20.859 (0.013)	19.380 (0.013)	21.739 (0.005)
Model selection	Fixed model	Fixed model	Fixed model	Fixed model	Fixed model	Fixed model	Fixed model
irpi	LLC (0.000)	LLC (0.000)	LLC (0.000)	LLC (0.000)	LLC (0.000)	LLC (0.000)	LLC (0.000)

From the regression coefficients of model (2) (4) (5), there is a significant negative relationship between the public attention and the efficiency of enterprise innovation, while the square of public attention has a significant positive relationship with the innovation efficiency of enterprises. It shows that there is a "U" relationship between public attention and enterprise innovation efficiency. This shows that lower public attention will not pose a threat to the enterprise. As the public attaches more importance to the environment, in order to survive, the enterprise has to meet the green demand of consumers and promote the innovation efficiency through the improvement of the production process. As can be seen from the model (3) (6) and (7), media coverage has a significant negative impact and business innovation efficiency, which indicating that media attention is not conducive to the improvement of enterprise innovation efficiency. This is contrary to Xu's conclusion^[19]. This shows that the existing public opinion about the environment in our country is still not perfect. In order to win the eyeball, the news media tend to report on the environmental performance of the enterprises, while the reports on the pollution incidents are few, which shows that the media has not played a public opinion on the environmental protection of listed companies supervisory role, therefore, can not force companies to innovate^[21]. In the model (1) to (7), the relationship between the return of the government direct subsidy intensity and the innovation efficiency is not significant, which shows that the government direct subsidy has not played a significant role in the innovation efficiency of enterprises. This conclusion negatives for the following reasons: First, because the government lacks supervision over the use of R & D subsidies, resulting in a lack of R & D subsidy efficiency and can not play a role in promoting enterprise innovation. Second, as the government increases R & D subsidy will lead companies to reduce their R & D investment accordingly. However, there is a significant positive impact on the relationship between government tax preference and enterprise technology. It shows that the preferential tax policies provided by the government have a strong incentive effect on the technological innovation of listed companies in manufacturing industry in China. Zhang et al. Found that tax incentives can promote high-tech enterprises to increase R & D investment by reducing costs, and through the substitution effect of relative price decline and encouraging the inflow of factors to generate the innovation efficiency to increase the value-added rate of high-tech enterprises^[15].

As can be seen from the model (4) (5) in Table 3, the interaction effect between the public attention degree and the strength of direct government subsidies and the intensity of government tax incentives is insignificant. they negate hypothesis 5 and hypothesis 6. As can be seen from model (6) in table 3, the interaction effect between media attention and government direct subsidy intensity is significant. The regression coefficient of the interaction term of is positive, indicating that when the government direct subsidy intensity is high, media attention will positively affect the efficiency of corporate innovation. As can be seen from model (7) of table 3, it shows that when the government tax incentives intensity is high, media attention has a positive effect on the efficiency of enterprise innovation. This shows that when government innovation support exists, social attention has no significant impact on the efficiency of enterprise innovation, while media attention has formed a good complementary effect with government innovation support, which can promote the innovation efficiency of enterprises.

4.2.2 Analysis of the impact of different levels of pollution

According to the different degree of pollution, the listed manufacturing companies are divided into two

groups: pollution-intensive and clean-production enterprises, to discuss whether environmental regulation and government innovation support will have different impacts on the innovation performance of different types of manufacturing listed companies. Therefore, on the basis of the full sample model, regression analysis is performed on the two types of grouping samples. The results are shown in Table 4 and Table 5.

Table 4 Pollution-intensive Enterprises Empirical Test Results

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
<i>irpi</i>	-0.139	-0.622*		-0.597*	-0.622*		
<i>irpi</i> ²		0.440		0.414	-0.437		
<i>irpo</i>			-0.018			-0.038	-0.207
<i>gds</i>	-0.025	-0.025	-0.020	-0.029	-0.027	-0.025	-0.009
<i>gtp</i>	0.198*	0.189*	0.205**	0.185*	0.189*	0.203**	0.140
<i>size</i>	-0.525	-0.523	-0.533	-0.517	-0.522	-0.534	-0.501
<i>age</i>	0.173	0.222	0.155	0.202	0.221	0.156	0.167
<i>alr</i>	-0.490***	-0.472***	-0.499***	-0.476***	-0.472***	-0.499***	-0.497***
<i>pro</i>	-0.159**	-0.149*	-0.173**	-0.163*	-0.149*	-0.173**	-0.182**
<i>irpi</i> × <i>gds</i>				0.004			
<i>irpi</i> × <i>gtp</i>					0.009		
<i>irpo</i> × <i>gds</i>						0.033	
<i>irpo</i> × <i>gtp</i>							0.277*
Redundancy test	1.212 (0.136)	1.228 (0.121)	1.196 (0.152)	1.240 (0.110)	1.228 (0.121)	1.173 (0.180)	1.243 (0.108)
Hausman test	13.243 (0.066)	19.350 (0.022)	12.998 (0.072)	20.426 (0.016)	19.350 (0.022)	13.255 (0.103)	17.690 (0.024)
Model selection	Fixed model	Fixed model	Fixed model	Fixed model	Fixed model	Fixed model	Fixed model

According to the model (1) (2) (4) and (5) of table (6), public attention has a significant negative impact on the efficiency of enterprise innovation, indicating that the higher the public concern, the less conducive to technological upgrading of enterprises And innovation. According to the models (3) (6) and (7), we find that the media attention is negative on the innovation efficiency of the pollution-intensive industries, but the effect is not significant enough. From models (1) to (7), it is found that only the intensity of tax incentives will have a significant negative impact on the innovation efficiency of the pollution-intensive enterprises, whereas the direct government subsidy of the government has no obvious effect on the innovation efficiency of the pollution-intensive enterprises influences. It can be seen from the model (7) that the interaction effect of the media attention degree and the tax preference has a significant positive impact on the innovation efficiency of enterprises, indicating that when the tax incentives intensity is large, the media attention can positively promote the innovation efficiency of enterprises. Other interactions are not significant.

Table 5 Cleaner Production Enterprise Empirical Test Table

Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
<i>irpi</i>	-0.017	-0.010		-0.044	-0.015		
<i>irpi</i> ²		0.036		-0.318	0.018		
<i>irpo</i>			0.056			0.059	0.034
<i>gds</i>	-0.025	-0.057	-0.086	-0.180	-0.053	-0.098	-0.064
<i>gtp</i>	0.198*	0.174*	0.178*	-0.103	0.172*	0.176*	0.180
<i>size</i>	-0.525	-0.004	-0.046	-0.046	-0.017	-0.058	-0.023
<i>age</i>	0.173	-0.031	-0.028	0.232	-0.032	-0.046	-0.032
<i>alr</i>	-0.490***	-0.012	-0.010	-0.095	-0.014	-0.008	-0.017
<i>pro</i>	-0.159**	-0.065	0.055	0.700***	0.052	0.056	0.041
<i>irpi</i> × <i>gds</i>				0.259**			
<i>irpi</i> × <i>gtp</i>					0.021		

Table 5, cont.

$irpo \times gds$						0.055	
$irpo \times gtp$							-0.053
Redundancy test	1.212 (0.136)	1.395 (0.115)	1.444 (0.093)	1.612 (0.043)	1.478 (0.081)	1.416 (0.105)	1.428 (0.100)
Hausman test	13.243 (0.066)	11.770 (0.162)	12.910 (0.074)	18.621 (0.029)	17.116 (0.047)	12.285 (0.139)	13.837 (0.086)
Model selection	Fixed model	Fixed model	Fixed model	Fixed model	Fixed model	Fixed model	Fixed model

Table 5 shows that in the cleaner production industry, the informal environmental regulation has no obvious effect on the innovation efficiency of the enterprises, which shows that the cleaner-production enterprises themselves are less polluted and less susceptible to public pressure. The effect of government direct subsidy on innovation of enterprises is not significant enough. The government's preferential tax policies have a significant positive impact on the innovation efficiency of enterprises. As for the interaction effects, it can be seen from the table that only the interaction between public attention and direct government subsidy in model (4) is significantly positive, indicating that when the direct government subsidy is high, the environmental regulation will positively affect the efficiency of enterprise innovation .

5 conclusions and policy recommendations

First of all, under the manufacturing industry in general, public attention and business innovation efficiency show "U" type, media attention and business innovation efficiency show a significant negative relationship. Therefore, the government should properly guide social public opinion to raise public awareness of environmental pollution in enterprises and give certain reward to public supervision. At the same time, we will improve laws and policies on news media coverage and avoid over-reporting by the news media of negative news about the corporate environment. In the case of classification, informal environmental regulation has an impact on the polluting industries. Therefore, the government should correctly guide public opinions in polluting industries and give more support to enterprises to ease the pressure on enterprises. At the same time, enterprises should also actively cooperate with the government, complying with the relevant policies and regulations.

Second, under the overall manufacturing industry, direct government subsidies have no significant impact on the efficiency of corporate innovation. Tax incentives have a significant positive impact on innovation efficiency. The government should appropriately reduce the direct financial subsidies and provide more tax incentives. In polluting enterprises, direct government subsidies do not encourage enterprises to upgrade their technology, and tax incentives have a negative impact on the innovation efficiency of enterprises. Therefore, the government can strengthen the proportion of venture capital to enterprises, standardize the competition mechanism of government procurement, and guide financial institutions such as policy banks to support high and new technology enterprises. In the case of cleaner production enterprises, direct government subsidies have no significant effect on the efficiency of corporate innovation, and tax incentives positively affect the efficiency of corporate innovation. Therefore, the government should give more tax incentives to encourage enterprises to continue to innovate. At the same time, enterprises should also increase their own capital investment and absorption capacity, so as to achieve good results.

In the manufacturing industry as a whole, under the informal environmental regulation , the media attention degree has significant interaction with tax incentives and the media attention degree has significant interaction with direct government subsidies, and is positive. Other interactions are not significant enough, so the government should guide aggressive social media attention to corporate environmental pollution. In the case of sub-sectors, the situation of the pollution-intensive enterprises is consistent with the general situation. In the case of cleaner production enterprises, the government should actively guide the public's attention to the business environment, forcing enterprises to upgrade their technology. National innovation not only needs to rely on the efforts of various industries and enterprises, but also requires the government to adopt some flexible and innovative management tools.

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