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The Impact of Environmental Regulations on Technology Innovation of Coastal Areas

-- An Empirical Analysis based on China's Coastal Area Data

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Abstract

The author uses the panel data of coastal areas in China from 2005 to 2015 to empirically test the impact of environmental regulations on technological innovation of coastal areas, then discusses the impact of environmental regulations on the number of invention and innovation patent applications, utility model patent applications, the individual influence of the number of design patent applications received. The research results show that environmental regulations have played a significant role in promoting the coastal areas' overall number of patent applications received, invention patent applications received, utility model patent applications received, and design patent applications received.

Keywords

Environmental Regulations; Coastal Areas; Technology Innovation.

1. Introduction

Since the reform and opening up in 1978, China's economy has made unprecedented achievements. Among them, the coastal areas have performed most prominently in the past 30 years, the most shining place of China's economy has appeared in the coastal areas. The development of coastal areas is of particular significance to the economic growth of China as a whole. However the environmental conditions of coastal areas are deteriorating day by day. In order to coordinate economic development and environmental protection, the government has issued a series of strict environmental laws and regulations. However, What impact will environmental regulations have on coastal areas' technological innovation? This is the question to be studied in this paper.

2. Literature Review

Traditional economic theory believes that environmental protection and economic development cannot be achieved at the same time, and environmental protection is bound to have an adverse effect on a country's economic growth. The so-called cost-compliance theory is that environmental protection is bound to increase the production cost of an enterprise. The increase in production cost will reduce the output of the enterprise and thus reduce the competitiveness of a country's products in the international market (Jorgenson, 1999)[3]. Porter (1991; 1995) [1-2] challenged traditional economic theory. Through case analysis, he found that strict and appropriate environmental regulations will lead to corporate innovation, partially or even completely offset the increase in corporate costs caused by environmental regulations, thereby increasing the productivity and competitiveness of enterprises, that is, "Porter Hypothesis." Through strict and appropriate environmental regulations, a "win-win" of environmental protection and economic development can be achieved.

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2.1. Environmental Regulation Will Promote Technological Innovation

Lanjouw and Mody (1996) investigated the relationship between environmental regulation and the invention and diffusion of environmental technology in the 1970s and 1980s in the United States, Japan, and Germany. The research results show that pollution control expenditures and the number of environmental patents are positive. Relatedly, the number of environmental patents increases with the increase in pollution control expenditures, and the technological innovation effect of environmental regulation has a lag of 1-2 years[4]. Jaffe and Palmer (1997) used relevant data from the US manufacturing industry from 1975 to 1991 to study the impact of environmental regulations on R&D expenditure and the number of patent applications. The results show that pollution control costs are positively correlated with R&D expenditures, while pollution control costs have no significant relationship with the number of patent applications [5]. BrunnerMeier and Cohen (2003) used panel data to empirically analyze the relationship between environmental regulations and industrial technological innovation in 146 manufacturing industries in the United States from 1983 to 1992. The empirical results show that pollution control costs are positively related to environmental patents[6]. The research of Ricci (2007) found that environmental regulations can help improve the level of environmentally friendly technologies. Popp & Newell (2012) pointed out that environmentally friendly technological advancements brought about by environmental regulations cannot offset the loss of total factor productivity [7]. Jaffe & Palmer (1997), Hamamoto (2006), etc. found that environmental regulations in some industries can help improve the overall level of research and development. Domestic research on environmental regulation and technological innovation started relatively late [5]. Li(2014) used the panel data of 37 sub-sectors of China's industry from 2004 to 2011 and found that both short-term and long-term environmental regulations have a significant promotion effect on enterprises' technological innovation capabilities[19]. Sen (2015) studied the automobile industry in 48 countries, and Zhao and Sun (2016) studied China's pollution-intensive enterprises, and both concluded that environmental regulations have a positive impact on technological innovation[8-9]. Yu(2017) empirically tested the relationship between environmental regulation, technological innovation and industrial operation performance with 37 industrial industries in my country as the research object. The results showed that strict environmental protection policies can induce industrial enterprises to carry out technological innovation. The effect of regulatory R&D investment is still insufficient, and it cannot promote the performance of industrial operations[12]. Shi (2018) used a nonlinear panel threshold model to empirically test the impact of environmental regulations and technological innovation on the upgrading of industrial structure. Studies have shown that high-strength environmental regulations have an adverse effect on technological innovation [10].

2.2. Environmental Regulations Inhibit Technological Innovation

Environmental regulations have an inhibiting effect on technological innovation (Ramanathan et al., 2010). The impact of environmental regulations on technological innovation has a U-shaped characteristic (Jiang, 2013; Liu, 2017)[21,11]. The research and development-induced effects of China's environmental regulations are not sufficient (Yu, 2017)[12]. The above empirical research results show that environmental regulations have a negative impact on corporate technological innovation and thus affect corporate performance. Following the cost theory is partially confirmed.

2.3. Uncertainty of the Impact of Environmental Regulations on Technological Innovation

Huang and Liu (2006) introduced technical coefficients into the Robert model to examine the relationship between environmental governance and production efficiency. Environmental

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regulations not only increase corporate costs, but also stimulate corporate technological innovation. Zhao's (2008) research found that the stimulating effect of environmental regulations on enterprise technological innovation only appeared in the medium and long term [9]. Jiang and Lu (2011) analyzed the impact of environmental regulations on China's three types of technological innovation capabilities, and the results showed that environmental regulations have no significant positive impact on my country's technological innovation. Research by Jiang (2013) shows that the relationship between environmental regulation and enterprise technological innovation presents a U-shaped dynamic characteristic of first decline and then increase[21]. Research by Liu and Ran (2015) shows that the impact of environmental regulations on the progress of production technology in different industries is different. Some industries have a significant "U" or inverted "U" relationship; other industries have no significant relationship. Zhang(2015) found that the environmental regulation intensity change rate of three different pollutants has two threshold effects on the change rate of production technology progress[23]. Only a moderate environmental regulation intensity change rate can promote the progress of production technology. The threshold value of the change rate index of the intensity of environmental regulation is quite different. Tao(2016) research shows that there is an inverted U-shaped relationship between environmental regulations and technological development[18]. Research by Wang(2018) shows that the intensity of environmental regulation has a significant negative correlation with green product innovation, and a significant positive correlation with green industrial innovation[24].

3. Model and Empirical Test

3.1. Index Selection and Data Explanation

3.1.1. Measurement of Environmental Regulations

At present, it is difficult to obtain direct data on environmental regulatory measures. The existing literature has adopted a variety of alternative indicators to measure environmental regulations. One is to adopt quantitative indicators to measure the intensity of environmental regulations. The most commonly used are: using GDP per capita as an alternative indicator of environmental regulations; using the emission intensity of different pollutants as an indicator to measure the intensity of a country's environmental regulations, that is, the higher the pollution emission intensity, the stricter the environmental regulatory measures; the adoption of environmental governance costs Quantitative indicators are used as substitute variables (Zhang, 2011)[23]; they are measured by operating costs of pollution control facilities. The second is to adopt qualitative indicators such as urban environmental governance compliance status and environmental subsidy policies to reflect the intensity of environmental regulations. In this paper, pollutant emissions (total emissions of ammonia nitrogen) are taken as proxy indicators for environmental regulations, and logarithmic processing is performed to eliminate heteroscedasticity in the data.

3.1.2. The Measurement of Technological Innovation

Many scholars use the level of R&D investment and the number of scientific researchers as indicators to measure innovation capabilities. Xie(2016) uses the three dimensions of technological innovation input, technological innovation output and technological innovation sustainability to be measured[14]. The technological innovation input indicator is expressed by R&D expenditure, and the technological innovation output indicator is expressed by the amount of patent authorization. Sustainability is represented by the number of college students per 10,000, and finally the entropy method is used for objective weighting, and the assigned index values are added to determine the level of technological innovation. Tao(2016) measures technological innovation capabilities from two stages: technology development and technology transformation[18]. Patent is an important indicator for an enterprise from resource

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investment to realization of technological development capabilities. Taking into account the availability of indicators, this article adopts the number of patent applications accepted by provinces and cities, the number of invention patent applications, the number of utility model patent applications, and the acceptance of design applications. The four aspects of quantity respectively measure the overall technological innovation and invention technological innovation, utility model technological innovation and appearance design technological innovation of each province and city. The more patent applications accepted, the stronger the technological innovation capability of the company.

3.1.3. Selection of Control Variables

In order to control the impact of key factors on technological innovation, this paper also introduces five indicators of fixed asset investment, urbanization, foreign economic openness, fiscal expenditure, and foreign direct investment to control the impact of key factors on technological innovation. Influence to enhance the interpretation of the model. Among them, the ratio of fixed asset investment to GDP is selected to measure the fixed asset investment of a region; the ratio of urban population to year-end permanent population is selected to reflect the urbanization progress of a region; the ratio of total import and export to GDP is selected to measure a region's external The level of economic openness; select the ratio of provincial fiscal expenditure to GDP to represent the fiscal expenditure of a region; select the actual use of foreign direct investment to GDP to measure the level of foreign direct investment in a region.

3.1.4. Model Setting

In order to comprehensively examine the relationship between environmental regulations and technological innovation, the following four model double log models were originally established:

$$lnPapplication_{it} = \alpha_0 + \alpha_1 * lnER_{i,t-1} + \alpha_2 * X_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

$$lnIapplication_{it} = \beta_0 + \beta_1 * lnER_{i,t-1} + \beta_2 * X_{i,t-1} + \varepsilon_{i,t} \quad (2)$$

$$lnUapplication_{it} = \gamma_0 + \gamma_1 * lnER_{i,t-1} + \gamma_{32} * X_{i,t-1} + \varepsilon_{i,t} \quad (3)$$

$$lnDapplication_{it} = \delta_0 + \delta_1 * lnER_{i,t-1} + \delta_2 * X_{i,t-1} + \varepsilon_{i,t} \quad (4)$$

$\boldsymbol{lnPapplication_{it}}$ represents the natural logarithm of the number of patent applications received, $lnIapplication_{it}$ represents the natural logarithm of invention patent applications accepted, $\boldsymbol{lnUapplication_{it}}$ represents the natural logarithm of the number of utility model patent applications accepted, $\boldsymbol{lnDapplication_{it}}$ represents the natural logarithm of the number of design applications accepted, $\boldsymbol{lnER_{i,t-1}}$ is representing the lagging period of environmental regulation, $\boldsymbol{X_{i,t-1}}$ represents the lagging period of the control variables (5 indicators of fixed asset investment, urbanization, foreign economic openness, fiscal expenditure, and foreign direct investment), $\boldsymbol{\alpha_i}$,$\boldsymbol{\beta_i}$,$\boldsymbol{\gamma_i}$, $\boldsymbol{\delta_i}$ **(i=0, 1, 2)** respectively represent their respective regression coefficients, $\boldsymbol{\varepsilon_{i,t}}$ represents the random error term.

3.2. Empirical Results

3.2.1. Descriptive Statistics of Variables

The research object of this paper is coastal areas (including 45 prefecture-level cities), the sample interval is from 2005 to 2015. The data comes from the website of the National Bureau of Statistics, "China Environmental Statistics Yearbook", wind database, "China Science and Technology Statistics Yearbook" and the sub-bank environmental protection statistical database of China Environmental Protection Database. The descriptive statistics of each variable are shown in Table 1: Due to the absolute number of technical innovation indicators

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(patent applications accepted, invention patent applications accepted, utility model patent applications accepted, design patent applications accepted), environmental regulations, etc. There is a big difference. This article uses logarithmic processing to reduce data instability and eliminate heteroscedasticity. The standard deviations are 1.730, 1.810, 1.760, 1.740 and 0.980, respectively.

Table 1. Descriptive Statistics of Variables

Variables	Average	Standard deviation	Min	Median	Max
lnIapplication	8.280	1.740	2.480	8.410	11.95
lnUapplication	8.590	1.760	3	8.770	11.95
lnDapplication	8.020	1.810	3.330	8.230	12.45
lnPapplication	9.490	1.730	4.490	9.610	13.13
lnANE	1.430	0.980	-2.300	1.610	3.140
Investment	0.660	0.210	0.250	0.660	1.330
Urban	0.510	0.150	0.210	0.490	0.900
Open	0.320	0.400	0.0400	0.140	1.720
FDI	22712	18929	4.240	17296	81914
expenditure	0.240	0.180	0.0800	0.200	1.350

Data Sources: "National Bureau of Statistics", "China Science and Technology Statistics Yearbook"

3.2.2. Correlation Coefficient Matrix of Variables

Table 2. Correlation Coefficient Matrix of Variables

lnIapp~n	lnANE	Invest~t	Urban	Open	FDI	expenditure	
lnIapplica~n	1						
lnANE	0.721***	1					
Investment	-0.160***	-0.113**	1				
Urban	0.649***	0.201***	-0.328***	1			
Open	0.482***	0.041	-0.583***	0.768***	1		
FDI	0.237***	0.090*	-0.210***	0.379***	0.301***	1	
expenditure	-0.539***	-0.667***	0.495***	-0.398***	0.238***	-0.326***	1

Data Sources: "National Bureau of Statistics", "China Science and Technology Statistics Yearbook"

3.2.3. Regression Results of Environmental Regulations on Technological Innovation of Coastal Areas

First, the number of patent applications accepted is used as a measure of technological innovation, and environmental regulations are used to perform regression analysis on technological innovation. The regression results show that: the number of patent applications accepted is positively correlated with environmental regulations. Significant at the 1% level. It shows that the current level of environmental regulation can play a positive role in promoting technological innovation. Fixed asset investment and urbanization also play a positive role in promoting technological innovation. It shows that the more investment in fixed assets in a region, the better the development of urbanization. The more it can promote regional technological innovation, this may be because the better the infrastructure investment and construction of a region, the higher the level of urbanization, the better it can attract the introduction of high-quality talents, which will positively promote and promote the technological innovation of a region. The degree of economic opening to the outside world is negatively correlated with technological innovation. This may be related to the extensive foreign trade development model that my country has formed over a long period of time. It only

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focuses on quantitative economic growth, and rarely raises the technical content of products from technological innovation. The way of trade development has caused great harm and negative impact on technological innovation in various regions of our country. Foreign direct investment has no significant impact on technological innovation, which is closely related to my country's foreign direct investment technology introduction, technology digestion and technology absorption capacity. The technology spillover effect of foreign direct investment has not been well brought into play. The impact of fiscal expenditure on technological innovation in a region is not significant, which is related to the fiscal expenditure structure of each region. Then, the number of patent applications received is divided into three aspects: invention patent applications received, utility model patent applications received, and design patent applications received. The environmental regulations are divided into the number of invention patent applications received, the number of utility model patent applications, and Regression analysis was conducted on the number of design applications received, and similar conclusions were reached. The difference is that the degree of economic openness has no significant impact on the number of design patent applications received, which is also in line with common sense.

Table 3. Regression Results of Environmental Regulations on Technological Innovation

Independent Variable	patent applications	Invention patent	utility model patent	Appearance design patent
ER	0.239***	0.239***	0.361***	0.141
	(4.06)	(4.06)	(6.24)	(1.28)
Investment	0.498**	0.498**	0.331*	0.817**
	(2.53)	(2.53)	(1.72)	(2.23)
Urban	13.265***	13.265***	13.340***	8.095***
	(16.02)	(16.02)	(16.41)	(5.25)
OPEN	-0.698***	-0.698***	-1.116***	-0.156
	(-4.67)	(-4.67)	(-7.61)	(-0.56)
FDI	0.000	0.000	-0.000	0.000
	(0.88)	(0.88)	(-0.49)	(0.36)
expenditure	0.258	0.258	0.567*	-0.513
	(0.75)	(0.75)	(1.68)	(-0.80)
Constant	2.198***	2.198***	1.313***	3.309***
	(6.85)	(6.85)	(4.17)	(5.54)
r2_a	0.877	0.877	0.894	0.451
F	406.050	406.050	478.154	52.120

Data Sources: "National Bureau of Statistics", "China Science and Technology Statistics Yearbook", "China Environmental Statistics Yearbook"

4. Conclusion

Based on the double logarithmic model analysis method, this paper uses panel data of coastal areas in China to conduct an empirical analysis on the relationship between environmental regulation and technological innovation, and draws the following conclusions: Environmental regulation has a positive effect on technological innovation in coastal areas in China. The promotion effect supports the idea that strict and adaptive environmental regulations proposed by the "Porter Hypothesis" will lead to technological innovation. Environmental regulations have a significant positive effect on the number of patent applications received, the number of invention patent applications granted, the number of utility model patent applications received, and the number of design applications received. Fixed asset investment

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and urbanization both have a significant positive impact on technological innovation in some coastal areas. Regional technological innovation is negatively correlated with a region's openness to the outside world. Foreign direct investment has no significant impact on technological innovation, and foreign direct investment has not been brought into play. Technology spillover effects of enterprises. The impact of fiscal expenditure on technological innovation is positive but not significant. In order to further promote regional technological innovation and promote the upgrading of regional industrial structure, on the basis of maintaining appropriate environmental regulations, we can continuously optimize the regional basic design and hard environment construction, improve the urbanization level of the region, optimize the structure of foreign trade, and improve the technology of foreign direct investment. For spillover benefits, fiscal expenditures are tilted to industries and enterprises that are technologically innovative, and more policy preferences are given to further promote regional technological innovation capabilities.

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