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Study on the Threshold Effect of Environmental Tax on Green Innovation

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Abstract: Based on the panel data of 30 provinces in China from 2009 to 2019, this paper studies the spatial spillover characteristic threshold characteristics of green innovation based on the threshold effect model. The study found that: First of all, environmental tax has a threshold effect on regional green innovation, that is, when the environmental tax is less than the threshold value of 0.0145, the environmental tax can significantly increase the regional green innovation; when the environmental tax reaches the threshold value of 0.0145, the environmental tax cannot effectively improve the regional green innovation. Clarifying the relationship between the two will help to reveal the policy effect of environmental tax in a more comprehensive and in-depth manner, and is conducive to promoting the coordinated development of regional economy and environment, technological innovation and high-quality economic development.

Keywords: Environmental tax, Regional green innovation, Threshold effect.

1. Introduction

The Fifth Plenary Session of the 19th Central Committee of the Communist Party of China stressed the need to "strengthen legal and policy guarantees for green development." As an important tool of environmental regulation, environmental protection taxes have been introduced in terms of reducing pollution emissions and promoting green innovation since they were introduced. The policy purpose of environmental protection taxation is to protect and improve the natural environment and reduce pollution emissions, but to fundamentally achieve this purpose, enterprises must be required to change their awareness of passive tax payment and consciously choose green methods with better emission reduction benefits. Whether the environmental tax can encourage small and medium-sized enterprises to carry out activities such as green adoption and technological innovation is the key criterion for judging the effectiveness of the environmental tax policy. Therefore, considering the impact of environmental protection taxes on the development of regional green and innovative economies, it is of great practical significance for improving the country's pollution reduction measures, enhancing technological innovation, building ecological civilization communities, and promoting the continued rapid development of economy and society.

Environmental taxes can be traced back to the Pigou tax law advocated by the French welfare economist Pigou[1](1991). As early as the beginning of the twentieth century, Pigou, the most famous environmental welfare economist at that time, clearly put forward the definition of private costs and social costs, arguing that minimizing personal costs does not necessarily maximize the resource cost of the whole society, but should be levied on the relevant polluters according to the degree of pollution of the natural environment, which can alleviate the external characteristics of environmental pollution and thus improve environmental quality; In addition, it can also improve the allocation of resources, thereby correcting the failure of the allocation of market resources. On how environmental taxes encourage green entrepreneurial activities in Chinese companies, the views of the researchers are roughly reflected in the following.

1.1. Positive Action

First, the environmental protection tax can also produce the compensation effect of enterprise innovation, encouraging enterprises to increase competitive advantage and market share, and the green management technology innovation, that is, the environmental tax can promote green innovation behavior, which is the content of the Porter effect. Porter [2] (1995) found that regulations that protect the environment can significantly promote green innovation in the region. Chintrakarn[3](2008). Calel[4] (2016) came to the same conclusion through studies in the United States and the European Union, respectively. Domestic scholars Sheng Yanchao [5] (2013) and He Huanlang [6] (2015) have analyzed China and concluded that environmental taxes are more likely to induce green innovation in enterprises than other policies. Bi Qian[7] (2016), Cao Xia [8] (2017), etc. used different analysis methods to conclude that increasing the amount of environmental tax collection can significantly improve the level of green innovation of enterprises.

1.2. Negative Action

The second view is that the government's environmental tax policy will occupy the productive input of small and medium-sized enterprises, which will lead small and medium-sized enterprises to invest the resources that can originally carry out R&D technological innovation into non-productive environmental governance links, thereby inhibiting the green technology innovation of small and medium-sized enterprises. Zhang Ping [9] (2016) from the perspective of environmental tax and sewage charges respectively concluded that environmental taxes will increase additional production and operation costs for enterprises, which will produce a very obvious "crowding out effect", thereby weakening the motivation of enterprises to adopt green. Yu Haiyan [10] (2020) pointed out that if the net profit caused by green innovation to polluting enterprises is small, the level of policy collection cannot effectively incentivize small and medium-sized enterprises to innovate emission reduction technology, and the government's environmental tax policy will face the

dilemma of loss.

1.3. Nonlinear Action

The third view is that there is uncertainty about the impact of environmental taxes on corporate green innovation, that is, there is a non-linear correlation between the two. Li Wanhong[11] (2015) For the manufacturing industry, the driving effect of the "Porter hypothesis" is closely related to the level of economic development, and the underdeveloped provinces do not support the "Porter hypothesis" Zhang Qian[12] (2016) to evaluate the possible innovative effects of environmental legal regulation with GML algorithms based on directional distance functions, but empirical research results show that there is a nonlinear connection between environmental legal regulation and innovation effects. Li Xiangju [13] (2018) also established a scientific research basis for studying the relationship between regional competition, environmental protection taxation and enterprise green innovation, and the theoretical and empirical research results show that the effect of environmental taxation on enterprise green innovation is inverted "U" shape. That is to say, with the gradual increase of environmental tax pressure, the negative impact on enterprise green innovation will be reflected in the shift from containment to encouragement.

1.4. Summary

In summary, domestic and foreign scholars have conducted in-depth research on the effects of environmental tax policies from different dimensions such as environmental improvement and technological innovation, which provides useful ideas and important references for the research of this paper. However, there is still room for further breakthroughs in existing research at the following levels: First, the thesis that local government competition affects the implementation effect of environmental taxes has basically reached a consensus in theory, but a simple linear model is used to examine the nonlinear relationship between environmental taxes and enterprise green innovation. Based on this, this paper attempts to go deeper from the following aspects: establish a panel threshold regression model to test whether there is a nonlinear relationship between environmental tax and green innovation. Clarifying the relationship between the two will help to reveal the policy effect of environmental tax in a more comprehensive and in-depth manner, and is conducive to promoting the coordinated development of regional economy and environment, technological innovation and high-quality economic development. Therefore, the research in this paper has a very broad research prospect and application value.

2. Status Quo Analysis

China introduced an environmental protection tax in 2018, the tax law stipulates that the taxation standard for air pollutants is 1.2 yuan to 12 yuan per pollution equivalent, and the taxation standard for water pollutants is 1.4 yuan to 14 yuan per pollution equivalent. In the first year of environmental protection", nearly 60% of provinces (municipalities directly under the central government) raised the tax standard for taxable pollutants. Among them, Beijing, Tianjin, Hebei and Shanghai implement the most stringent environmental protection tax policies, and the tax amount is more than 5 times the minimum collection standard. In order to more graphically reflect the changes in the level of green innovation in different environmental protection tax areas, this paper is divided into four grades: low, low, medium and high according to the level of environmental protection tax rates in various places. Figure 1 reflects the level and changes in green innovation in different tax brackets. As you can see from the figure, the green innovation changes in regions that enforce different environmental tax rates are not consistent. In the first year of the introduction of the environmental protection tax in 2018, the initial stage of policy implementation was not significant, and the high-standard tax rate areas did not show the incentive effect of green innovation. By 2019, green innovation in different taxation standard areas has shown regular changes. With the environmental protection tax rate standard from low to high, the growth rate of green innovation (the number of green technology patents authorized by 10,000 R&D personnel) has increased step by step. According to preliminary judgments, there is a correlation between environmental protection taxes and regional green innovation.

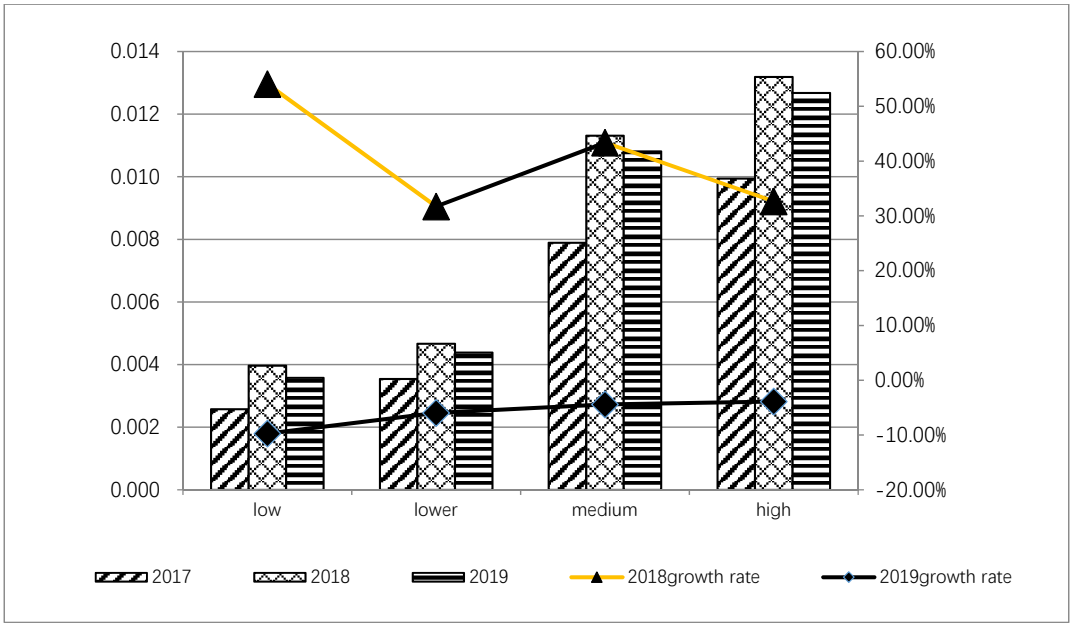

Figure 1. Green innovation in various provinces and cities

Note: According to the tax rate classification standard, the low-tax areas include: Liaoning, Jilin, Anhui, Fujian, Jiangxi, Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang, Yunnan, Heilongjiang, Inner Mongolia; The lower tax areas include Zhejiang, Hubei, Hunan, Guangdong, Guangxi, Guizhou, Shanxi, Hainan and Chongqing; The medium-rated areas include Jiangsu, Shandong, Sichuan and Henan; High-tax areas include Beijing, Tianjin, Hebei and Shanghai.

3. Empirical Testing

The manuscript should include a conclusion. In this section, summarize what was described in your paper. Future directions may also be included in this section. Authors are strongly encouraged not to reference multiple figures or tables in the conclusion; these should be referenced in the body of the paper.

3.1. Model Building

Hansen[14] (1999) proposed panel threshold regression model can not only accurately estimate the threshold value, but also carry out a significance test on the "threshold value", to a certain extent, to avoid the statistical error and regression bias caused by the subjective judgment threshold value, based on this, this paper uses the Hansen panel threshold regression model, empirically analyzes the threshold effect of environmental tax on regional green innovation, and establishes a threshold panel data model based on the threshold variable of government control.

$$gp_{it} = c + \beta_2 tec_{it} + \beta_3 urb_{it} + \beta_4 pollut_{it} + \beta_5 ind2_{it} + \beta_6 gov_{it} + \beta_{11} et_{it} I(et < \alpha) + \beta_{12} e_{it} I(et > \alpha) + \epsilon_{it} \quad (1)$$

3.2. Variable Selection and Data Sources

3.2.1. The Explanatory Variable

Green Innovation (PAT): Green innovation is a multi-stage process that includes both green innovation activities at the input stage and green innovation activities at the output stage. Considering the availability of data and the practical effects of green innovations. Referring to the practice of Dong Zhiqing and Wang Hui [15] (2019), this paper preliminarily selects the number of green technology applications of 10,000 R&D personnel in various provinces to measure the level of regional green innovation.

3.2.2. The Explanatory Variables

Environmental tax (et): Before the official introduction of environmental protection tax, China has been implementing a quasi-environmental tax (fee) system, that is, all taxes on environmental pollution and ecological protection in the current tax system are included (Li Xiangju, He Na [13], 2018), which belongs to the concept of environmental tax in a broad sense. The environmental tax in this article mainly refers to the environmental tax in a broad sense, including vehicle and vessel tax, land use tax, cultivated land occupation tax, urban maintenance and construction tax, vehicle purchase tax, resource tax and environmental protection tax (sewage fee). Empirically, environmental taxes are measured by the ratio of the sum of the above taxes and fees to GDP.

3.2.3. Control Variables and Instrument Variables

Refer to the literature of scholars in related fields, and select the following control variables: (1) Fixed asset investment level (fa): Measured by the proportion of fixed asset investment and GDP in each region; Level of urbanization (URB): measured by the ratio of urban population to total population in each region; (3) Industrial structure (sec): measured by the proportion of the output value of the secondary industry in each region to GDP; (4) Per capita R&D expenditure (rd): the ratio of R&D expenditure to population in each province is adopted; (5) Degree of openness: Measured by the proportion of total imports and exports to GDP.

To identify the causal relationship between environmental tax and regional green innovation, the biggest challenge lies in dealing with the endogenous problem of environmental tax, drawing on the practice of Dong Zhiqing and Wang Hui [22] (2019), we chose precipitation as a tool variable for environmental tax, as detailed in the endogenous treatment section below. The samples selected in this paper are panel data from 30 provinces, autonomous regions and municipalities directly under the Central Government (excluding Tibet, Hong Kong, Macao and Taiwan) from 2005 to 2019, of which the data on the number of green patents granted and the number of applications in each province are derived from the China Research Data Service Platform (CRNDS), and the tax revenue and sewage fee income are from the 2004-2020 China Tax Yearbook and the China Environmental Statistics Yearbook.

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4 Empirical Results

From the above analysis, we can conclude that environmental taxes have a threshold effect on green innovation, and in order to determine the number of threshold variables in the panel threshold model, we use Hansen's (1999) method to test, and the results are shown in Table 1. Table 5 shows that the single threshold model is significant while the remaining threshold models are not. Therefore, there is a single threshold for this article.

Table 1. Threshold effect test results

Number	F Value	P value
Single Threshold	12.60	0.0500
Double Threshold	4.63	0.5100
Triple Threshold	4.38	0.8900

The regression result of the single threshold panel is shown in Table 2: when the degree of government regulation is less than the threshold value of 0.0145, the environmental tax plays a leading role in the positive externalities of green innovation, and the environmental tax is conducive to regional green innovation. When the environmental tax is higher than the threshold of 0.0145, the environmental tax plays a leading role in the negative externalities of green innovation, at which time the environmental tax can reduce the level of regional innovation. This is due to the low level of government regulation, due to the existence of information asymmetry and negative externalities, polluters have incentives to continuously discharge pollutants to the outside world, government supervision is not in place, corporate tax awareness is weak, at this time even if the environmental tax is increased, it will not lead to an increase in the innovation capacity of the place, and the congestion effect dominates. It

can be seen that the impact of environmental taxes on green innovation is not a monotonous increase or a monotonous decline, but a "threshold" feature, and the two show an inverted "U" curve relationship.

Table 2. Threshold estimates and confidence intervals

Number	F Value	P value
Threshold estimate	0.0145	0.0070
Variable	et< 0.0145	et>=0.0145
et Estimate	0.2344	-0.0996

5 Policy Recommendations

First, according to the economic development and environmental carrying capacity, carefully and appropriately formulate local environmental tax rates. Since environmental tax has an inverted "U" characteristic of green innovation, therefore, except for Beijing, Tianjin and other areas with the highest or higher environmental tax rates, other regions should gradually increase the local environmental tax rate step by step and in stages according to the economic and environmental carrying capacity, so that the incentive effect of environmental tax on green innovation is maximized, thereby promoting industrial structure upgrading and improving overall environmental quality.

Second, improve the government environmental supervision system and promote coordinated regional environmental governance. Whether environmental policies can achieve environmental protection goals depends to a large extent on the government's environmental supervision system and law enforcement. In view of the current problems of incomplete local environmental supervision system and lax environmental law enforcement, the environmental supervision and management system, including central inspection, supervision and inspection, should be further improved, and the supervision and guidance of local environmental law enforcement should be strengthened to ensure the effective implementation of environmental policies.

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