Does Performance－Based Accountability Improve Green Technology Innovation? Spatial Econometric Study

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Abstract: Based on the theory of spatial econometrics, this paper focuses on the annual report of local government and empirically tests the relationship between performance-based accountability mechanisms and green technology innovation by means of the panel data from 30 provincial governments (2009-2016) from the perspective of organizational pressure-response theory. The finding shows that: Performance accountability has a certain role in promoting green technology innovation, but not enough. The personal characteristics of the chief executive of each region have a positive impact on the green product innovation and the green process innovation in the region. Performance goal setting has a certain promotion effect on the green process innovation.
Keywords: Spatial statistics; performance-based accountability; the annual report of local government; green technology innovation.

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1. INTRODUCTION

Since the reform and opening up, China's economy has developed rapidly, but the development model of high investment, high consumption and high emission has seriously damaged the environment and restricted the economic development. The relevant government departments have made a series of measures to deal with the situation: The 18th session of National Congress of the CPC proposes to vigorously promote the construction of ecological civilization and reverse the trend of the deterioration of the ecological environment; The 13th five year plan for national economic and social development includes the contents of strengthening the comprehensive management of the environment. The innovation-driven development has been the goal that China has pursued since the reform and opening up. The national government has implemented a series of strategies such as the construction of innovative country and innovation driven development. Under the present situation of innovation as the initiative of national development, how to reduce or eliminate environmental pollution and develop green environmental protection and innovation at the same time has become a major concern of governments at all levels. Performance accountability for the relationship between development and environmental protection has also become a hot topic in society. Green technology innovation is an important guarantee for achieving a win-win situation of economic growth and environmental protection [1]. The 19th session of National Congress of the CPC puts forward that scientific and technological innovation is an important engine for green

development. We should build a market oriented green technology innovation system and strengthen the energy saving and environmental protection industry, clean production industry and clean energy industry. Green technology innovation refers to the purpose of providing green products to the market by developing and using green technology that meets the requirements of environmental protection, so as to achieve the purpose of saving energy and protecting the environment. Green technology innovation can not only provide economic benefits from traditional technological innovation, but also alleviate or even eliminate environmental pollution in the process of production. It is a powerful tool to solve the problem of "economic + environment" development.

Scholars both at home and abroad have done a lot of research on performance accountability and green technology innovation. But the research on performance accountability is in the process of developing, there are few related articles. Foreign scholars mainly studied information disclosure of government operation and government accountability based on the government work report. Ralph believes that the responsiveness and responsibility of the government are the main concerns of the public and the government work report is a powerful tool for the government accountability [2]. Christine has found a correlation between the size of the local government and the quality of the report by measuring the quality of the annual report of the local government in Queensland, but the quality of the disclosure is not related to the timeliness of the report [3]. At the same time, some scholars have raised questions. Ilesna's empirical analysis of Italy local government samples find that the annual report does not seem to play the role of the "general" report, but only to perform detailed legal responsibilities and pay attention to the needs of the government's internal stakeholders[4]. Domestic scholars mainly study the impact of performance accountability on the basis of the annual work report of the government. For example, Zhu Guangxi believes that the local government should establish a reasonable index system in the performance evaluation and set up the operation mode of multi supervision [5]. Based on the panel data study of 30 provinces in mainland China during 2004-2011 years, Wu Jiannan etc has found that effectiveness construction has different effects on government performance in areas with different economic development levels [6]. Yan Bo etc using the empirical study on panel data of 31 provinces in China finds that performance accountability promotes regional innovation to a certain extent, but this effect is more dependent on the rational choice of the provincial governments [7].

In recent years, environmental problems have become more and more prominent, and green technology innovation has become a major concern on the domestic and International Symposium on the relationship between environment and development. Foreign scholars mainly discuss the restrictive factors of green technology innovation. For example, Lanjouw & Mody using the patents and data controlling pollution expenditure of the United States, Germany and Japan finds that the government regulation measuring pollution expenditure can promote green technology innovation [8]. Isik finds that green technology innovation will be influenced by the policy effectiveness using the option value model [8]. The domestic scholars have been involved in the research of green technology innovation in recent years, and mainly focus on the factors that affect the green technology innovation [9]. The empirical study on the panel data of 27 manufacturing industries by Bi Kexin etc has found that FDI has a negative impact on the two technological innovations of China's manufacturing industry [10]. Wang Wenpu&Chen Bin, based on the study of 31 provincial environmental patent panel data in mainland China, find that the overall environmental policy has a significant positive impact on green technology innovation, and the knowledge level also significantly promotes green technology innovation [11]. Wang Fengzheng etc using the panel data of 30 provinces in China during 2000-2011 years find that government quality and environmental regulation have significant impact on green technology innovation in enterprise, and the influence of

government quality on green technology innovation can be significantly regulated by the government quality [12].

Through the collation of relevant literature, few articles have been found to study the relationship between performance accountability and green technology innovation. The lag of theoretical research and the huge demand for green technological innovation activities have formed a sharp contrast. For China in the period of transition, the government attaches great importance to innovation. In recent years, the government has constantly stressed the implementation of the top-down accountability mechanism. It is the hope that the relevant cadres and units should pay more attention to promote the scientific and technological innovation activities in the region. Starting with the analysis of the performance accountability mechanism of local government annual work report, this paper adopts the spatial measurement model to explore the relationship between performance accountability and green technology innovation, hoping to get some useful conclusions to make up for the shortcomings of the existing research and to provide preliminary theoretical and empirical evidence for carrying out the government's implementation of strategies and policies related to green technology innovation.

2. RESEARCH DESIGN

2.1 2Research Method

Spatial econometrics mainly deal with the problems of spatial heterogeneity and correlation in regression models. The basic idea is to introduce interregional relations in the regression model and modify the spatial weight matrix. The spatial econometric model based on cross section data can not accommodate the heterogeneity of space units and easily produces errors, while the spatial panel data measurement model can avoid this error. There are two main forms of spatial panel data model: spatial lag model and spatial error model.

spatial lag model:

$$Y_t = \rho W Y_t + \beta X_t + \varepsilon_t \tag{1}$$

spatial error model:

$$Y_t = \beta X_t + \varepsilon_t + \mu \tag{2}$$

$$\varepsilon_t = \lambda * W * \varepsilon_t + \varphi_t \tag{3}$$

Where: Y_t represents N x 1 vectors composed of the observational values of the dependent variable of each space unit $i = 1,...,n$ in the t period. W is the $n \times n$ nonnegative space weight matrix that the elements on the diagonal are 0. WY_t is the first order lagging variable, which is an endogenous variable. X_t is the $n \times k$ matrix of the observation value of exogenous variables. ρ is spatial autoregressive parameter, which is presented with range in [-1,1]. $\mu = (\mu_1,...,\mu_n)^T$, $\varepsilon = (\varepsilon_{1t},...,\varepsilon_{nt})^T$ are random disturbance vectors. λ is spatial autocorrelation coefficient, which is presented with range in [-1,1]. φ_t is independent and identically distributed. $E(\varphi_t) = 0$, $E(\varphi_t \varphi_t^T) = \sigma^2 I_n$, I_n are n th order unit matrix.

Spatial weight matrix (W) represents the interdependence and correlation between space units. Based on the first law of Geography: There is a connection between everything and its surroundings, and the proximity is more closely connected than the distance far away, so this paper uses the following inverse distance weight matrix to reflect this relationship:

$$w_{ij} = \begin{cases} \dfrac{1}{d_{ij}^2} & i \neq j \\ 0 & i = j \end{cases} \tag{4}$$

Where: d_{ij} is the distance between the location of the geographical center of two areas. The inverse distance weight matrix considers that there is a spatial effect when the space unit is $i \neq j$, and its spatial effect attenuates faster with the increase of distance.

2.2 Variable Definition

2.2.1 Dependent Variable

Green technology innovation refers to the purpose of producing green products to the market by developing and using green technology that meets the requirements of environmental protection, so as to save resources and reduce or eliminate pollution[13], which mainly includes process innovation and product innovation. Green product innovation pays attention to the energy saving and emission reduction in each stage of product production and whether it meets the requirements of environmental protection. Therefore, this paper uses the sales revenue of new products of unit energy consumption to measure. Green process innovation is mainly concerned with the transformation and upgrade of production process equipment, which is measured by the internal expenditure of R&D funds and the investment of technical transformation funds in this paper[10].

2.2.2 Independent Variable

The annual report on the work of the government is an official document submitted by the executive heads of the provinces (municipalities and autonomous regions) to the presidents of the general assembly, the delegates of the people's Congress, the CPPCC members at the meeting of the local people's Congress and the Political Consultative Conference held at the beginning of the year. The main contents of the official documents are on the work of the past year. It is a typical form of performance accountability, and it also has the goal setting and specific arrangement of government work in the coming year. It is a typical form of performance accountability, which is judged by the stakeholders. The characteristics of the content and object of the accountability are the two basic aspects of describing performance accountability. This paper adopts a text frequency statistics method commonly used in the study of the relationship between subjects such as measurement mechanism and policy[14]. In the annual work report of each provincial government, the two parts of the "work review and summary" and "work goal and plan" are used to retrieve the similar key words of environmental protection, and the frequency of the two parts of the performance evaluation (X1) and the target setting (X2) was taken as the two independent variables that reflect the characteristics of the accountability content. For the object of accountability (L), it mainly examines whether the chief executive has the work experience of innovation, such as business, industry and technology management. It is the third independent variable which is set as a dumb variable that the relevant work experience is 1 and no relevant work experience is 0[7].

2.2.3 Control Variable

The regional distribution of green technology innovation level is uneven, similar to the current situation of China's economic development, and the level of regional economic development is an important factor that can not be ignored. Therefore, this paper introduces the per capita gross regional product (perGDP) to measure the level of regional economic development[15]. R&D personnel is an important resource for the development of R&D, and it has an important impact on the level of scientific and technological innovation in the region[16]. This paper selects the full time equivalent of R&D personnel(RD) in each region to measure the impact of R&D personnel on green technology innovation. In addition to the government work report, other social subjects, such as enterprises and citizens, have also caused pressure to the

government to a certain extent. The higher the education level of the residents, the higher the demand for the government. So this paper uses the degree of education for residents (EDU) to measure the public pressure.

2.3 Data Sources

The relevant data of the performance accountability in the independent variable comes from the work report and the people's network; The data of the variables and the control variables come from the Statistical Yearbook of China, the Yearbook of China's Scientific and Technological Statistics, the Statistical Yearbook of the Industrial Enterprise's Scientific and Technological Activities. When the annual work report is released, the local government usually takes a year to carry out all the work in the report. In order to improve the robustness of the model, this paper will adopt the lag phase variable. In other words, the data of the independent variable is taken from 2009 to 2015 and the variable data is taken from 2010 to 2016. Because this paper involves a large number of macroeconomic data, and this kind of data has large volatility, it is easy to lead to the generation of heteroscedasticity. We have a logarithmic process to reduce the disturbance to the analysis results.

3. EMPIRICAL ANALYSIS

In the 2.1 section, the spatial panel measurement model mainly includes spatial lag model and spatial error model. For the selection of the two models, the Lagrange multiplier test (LM test) and the robust LM test (Robust LM test) are usually used to select a group higher degree of significant range. The results of the application of MATLAB to each area are shown in Table 1.

Table 1. Test results in the form of spatial panel model

Test	Green product innovation	Green process innovation
LM-lag	37.269(0.000)	3.404(0.065)
Robust LM-lag	4.286(0.038)	0.000(0.984)
LM-error	36.649(0.000)	16.386(0.000)
Robust LM-error	3.666(0.056)	12.982(0.000)

Note: The value of p is in parentheses.

As can be seen in table 1 that spatial lag model should be adopted to study the impact of performance accountability on green product innovation, and spatial error model is adopted for green process innovation. The results of the specific model analysis are shown in Table 2.

Table 2. Results of performance accountability for green technology innovation

Variables	Green product innovation		Green process innovation	
	Coefficient	t	Coefficient	t
perGDP	0.137	1.527	-0.085	-1.093
RD	0.341***	6.689	0.801***	25.070
EDU	0.098***	1.095	-0.058	-1.426
L	0.058**	0.889	0.065***	1.820
X1	-0.018	-1.041	-0.002	-0.181
X2	-0.0003	-0.009	0.017**	2.033
λ	0.571***	8.740	0.543***	6.821
R2	0.8479	\	0.9521	\
logL	-156.6099	\	-11.879	\

Note: "*","**","***" marked at significant levels of 10%, 5%, and 1% respectively.

From table 2, the characteristics of the object of accountability have a significant positive impact on green product innovation and green process innovation. That is to say, when the district chief executive has been engaged in innovation related work, the level of green

technology innovation in the province is relatively high. Under the background of a highly centralized political system, the chief executive is the supreme leader of the regional government activities, whose personal experience and characteristics have an important guiding role in the way and content of the government's work. Regional leaders with innovation related experience are more concerned about green technology innovation than those without innovative experience in formulating policy and annual focus, because they have a deeper understanding of the role of innovation in promoting economic development. The increasing attention of the chief executive to green technology innovation makes the subordinate units and cadres raise the proportion of investment in R&D and technical transformation, and the technological level in the production process has been improved. The new product income per unit energy consumption will be increased, so as to stimulate the enthusiasm of enterprises to promote the development of green technology innovation.

The performance goal setting has a positive effect on the green process innovation. That is to say, the more the part of "work goals and plans" of the government work report on environmental protection and innovation, the greater the promotion of green process innovation. Performance accountability and innovation generally follow the logic of "pressure-response". When the chief executive gives the goals related to green technology innovation in the government work report at the beginning of the year, in order to obtain political achievements and resources, the subordinate units and cadres will meet their superiors' intentions and energetically encourage and support green technological innovation. Concentrating a large amount of human and material resources, investing a lot of scientific research funds to upgrade the production equipment and developing green technology to meet the requirements of environmental protection to complete the target of performance and promote the green technology innovation in the region.

The influence of other independent variables is not significant. Although performance accountability has a certain role in promoting green technology innovation, it is not sufficient. The performance accountability mechanism lacks effective public participation, which can not ensure the public's relative information superiority and easily lead to the blind blame for the decision-makers. At the 60th anniversary congress of the National People's Congress, President Xi stressed that "the government will not be slack only if the people are allowed to supervise the government".

4. CONCLUSION

Based on the perspective of organizational response to accountability and the annual work report of the government, this paper uses the panel data in 30 provinces of China for 2009-2016 to find that : (1) Performance accountability has a certain role in promoting green technology innovation, but not enough. (2)The personal characteristics of the provincial chief executives have significant positive effects on the green process innovation and green product innovation. hat is to say, when the chief executive has the experience of innovation, the level of green technology innovation in the province is relatively high. (3)The performance goal setting has a certain effect on the green process innovation.

In view of the above conclusions, the following policy suggestions are given:

1) Improving the information disclosure system and ensuring the information advantage of the public. The primary challenge for the performance accountability mechanism is how to ensure the full participation of the public so as to gain information advantage. Only when the relative information superiority of the public are guaranteed can the decision-makers think deeply and avoid blind and arrogant perfunctory. Therefore, we should improve the system of information disclosure of the annual work report, making clear provisions on disclosure time limit, data caliber, public channels and so on, improving the integrity, reliability, availability and

timeliness of information, ensuring the right to know and initiative to ensure public accountability and making full use of performance accountability to promote the green technology innovation.

2)The characteristics of local governments should be considered when designing accountability mechanisms. The local government plays an important role in promoting the development of green technology innovation. The decision-maker in the local government is in an important dominant position. Considering the conditions of local development and the constraints of "Responsible for the Superior", the decision-maker should be clear about the role orientation of the government work and its own preference degree to the understanding of the content of performance accountability, based on the provincial characteristics, closely following the national strategic decision and improving the performance of the green technology innovation.

3) Flexibility in implementing policy. The emphasis on green technology innovation in each province depends mainly on the choice of local government. The government work report at the beginning of the year will give the work goals and plans that meet its own characteristics and needs. Facing multi-dimensional provincial performance goals, the decision-makers should prioritize the performance goals that meet the needs of the superior and gain their own relevant interests based on the conditions of development of the province under the pressure of accountability.

4) Strengthening the ability of scientific and technological innovation and vigorously promoting the green technology innovation. Green development, as a developing way of high technology, low consumption of resources and less environmental pollution, can not be completed by traditional production knowledge and technology. Only through scientific and technological innovation can it be realized. Local governments should attach importance to the guiding and supporting role of scientific and technological innovation in green development. We should ensure that both technology and products conform to the concept of green development and implement green environmental protection from the source of scientific and technological innovation. The energy utilization rate is greatly improved and the resource consumption of the unit products is reduced only through the green technology innovation. It is the only way for the sustainable development to take the road of intensive economic development.

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