Association between spatial spillover of government R&D subsidies and regional economic growth

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Abstract. There is a certain promotion effect of government R&D subsidies on enterprises' innovation, and this promotion effect will have certain spillover effects on other regional economies through various channels. Based on the panel data of entrepreneurial small and medium-sized enterprises (SMEs) in 28 provinces from 2009 to 2019 and the dynamic spatial panel Durbin model, this paper investigates the spillover relationship between R&D innovation and R&D subsidies of entrepreneurial SMEs on regional economic growth. The results show that government R&D subsidies have a more significant positive spatial correlation on regional economic development, and R&D innovation of enterprises has a negative spatial correlation on regional economic development in general.

Keywords: R&D subsidies; regional economy; spatial Durbin model (SDM); spillover effects

1 Introduction

Today the world is in the era of scientific and technological innovation, and mastering core technologies has become an indispensable and essential factor in building national and regional core competitiveness. As a necessary means to master the core technology, innovation has become the central competitiveness for the development of Chinese enterprises, especially for SMEs. The Chinese government's R&D investment intensity for enterprises has exceeded 2% since 2014, of which the investment in research and experimental development has maintained rapid growth. [1] In recent years, the growth rate of SMEs in science and technology innovation has increased, which highlights the

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importance of the government to guarantee the smooth implementation of their R&D activities. [2] Currently, The Chinese Government's financial support policies for SME innovation mainly include direct government subsidies and tax incentives. [3] However, for the development of SMEs in different regions, the government's financial subsidies have different impacts on the local economy. Since the reform and opening up, China has indeed created the *Chinese miracle* in many aspects and achieved rapid economic development. However, due to long-term stimulating investment and cheap labor force, some problems have gradually emerged, such as low productivity, serious environmental pollution and uneven regional economic development. [4] Therefore, from the perspective of spatial spillover, this paper discusses the internal laws and dynamic mechanisms of government R&D subsidies and enterprise innovation as well as regional economic development, providing valuable references for regional economic and innovative development.

2 Literature Review

The impact of government R&D subsidies on SMEs' innovation is now mainly disputed by academics in two ways, one is that their R&D subsidies can promote firms' R&D innovation and the other that R&D subsidies have a crowding-out effect on firms' innovation. In terms of studying which subsidy policy the government adopts, Qilin, M et al.[4] measured the innovation intensity of firms by the proportion of new product sales to the total sales of firms, and then assessed the micro effects of government subsidies on firms' new product innovation. Chen, D analyzed and compared the incentive effects of tax incentives and government subsidies on firms' R&D activities from the perspective of firms' R&D activities. [5] According to the signaling theory, when the incentive effect is lower than the negative signal of *R&D risk*, the R&D subsidy will have a crowding-out effect on R&D innovation. [6] In the empirical research, some scholars found that government R&D subsidies also have spatial spillover effects on enterprise innovation, mainly in the area of the regional economy and regional R&D. In studying the impact of science and technology innovation on regional economic growth and its spatial spillover effect, Shu, L concluded that science and technology innovation could effectively boost local economic growth, and there are regional differences in its spatial spillover effect. [7] Combining the idea of K correlation in new economic geography, Xiongfeng, P et al. explored the spatial spillover effect of technological innovation among regions in China. They found that the national technological innovation spillover is mainly driven by the eastern region, and R&D funding, R&D personnel, and knowledge stock all have a positive effect on technological innovation. [8] Moreover, enterprise R&D investment is also spatially dependent. The economic distance-weighted average enterprise R&D investment in other regions, government R&D subsidies, and enterprise net profits will promote the increase of enterprise R&D investment in the region. [9] Lanyun, X found that there is a high spatial correlation between the economic growth of Chinese provinces and that the R&D investment of a province can influence the national economic growth directly or indirectly through four ways. [10]

The second part of this paper mainly summarizes the literature research of relevant scholars; The third part mainly describes the data used in this paper in detail; The fourth part is also the core part of this paper, mainly through the establishment of empirical models for data analysis, to get reliable research conclusions; The fifth part summarizes the empirical model on the basis of the fourth part, and gives policy suggestions with reference significance.

3 Data sources and variable selection

3.1 Data source

The data in this paper is mainly obtained from the CSMR database and the China Statistical Yearbook of the National Bureau of Statistics. In view of the fact that enterprises in the Growth Enterprise Market in China were officially listed on October 30 in 2009, and combined with the market characteristics, it is helpful for potential SMEs to obtain financing opportunities. Therefore, this paper selects 979 GEM enterprises in 28 provinces from 2009 to 2019 as the analysis object. Among them, the data on government R&D subsidies are obtained by hand screening based on the data remarks information of government subsidies in the CSMR database. The ST and ST* enterprises and enterprises with too many missing key indicators were also excluded to ensure the rigor of the data. For the screening of enterprises' provinces, enterprises in Hong Kong, Macau, and Taiwan are excluded due to the difficulty of obtaining data, and enterprises in Qinghai, Ningxia, and Tibet are also excluded due to the lack of government R&D subsidy data.

3.2 Variable selection

The article investigates the association between the spatial spillover effect of government R&D subsidies and regional economic growth. Therefore, in studying the spatial spillover model, the article takes regional economic growth as the explanatory variable and uses the logarithm of the per capita gross product of each province to measure it. In the article, government R&D subsidies, corporate R&D expenditures ($\ln k$), corporate R&D personnel ($\ln l$), and corporate patent applications ($\ln apply$) are used as core explanatory variables to measure R&D spillover from the financial and human perspectives, respectively. Among them, the indicators used as measures of corporate R&D innovation are corporate R&D expenditure, corporate R&D personnel, and the number of corporate patent applications. Table 1 shows the descriptive statistical analysis of the selected variables after taking logarithms.

Table 1. Descriptive statistics of variables

variable	mean	sd	min	N	max
lnrjGDP	9.900	0.710	7.630	280	11.59
lnapply	3.300	2.390	0	280	8.080
lnk	19.02	3.290	0	280	23.88
lnsub	16.79	3.720	0	280	21.34
lnl	4.280	3.910	0	280	11.39

4 Empirical Analysis

This paper uses a spatial economic model based on panel data to study the spillover effects of R&D subsidies and corporate innovation. Firstly, Moran's I index is used to testing the spatial correlation. It can be found from the Table 2 that the Moran's I of p-value is significant at 1% level, so we can draw a conclusion that the per capita GDP measuring the level of regional economic development has a strong positive correlation. Then through LM Test, Wald Test, and LR Test. Finally, the spillover effect was analyzed using the spatial Durbin model (SDM). Due to space constraints, these tests results will not be displayed here. The SDM model developed is shown below:

$$Y_{it} = \alpha + \beta_1 ln\, s\, ub_i + \beta_2 ln\, k_i + \beta_3 ln\, l_i + \beta_4 ln\, a\, pply_i + \theta_i \sum_{i=1}^{n} WX_{it} + \theta_i \sum_{i=1}^{n} WY_i + \varepsilon_{it} \quad (1)$$

In the above equation, i represents the region, t represents the year, Y_{it} is the regional economic development level of province i in period t (28×1 order), α is a constant term, $\ln sub_i$, $\ln k_i$, $\ln apply_i$, $\ln l_i$ are the explanatory variables R&D subsidy, enterprise R&D expenditure, enterprise patent application, enterprise R&D personnel (10×28 order), W is the spatial weight matrix (28×28 order), this paper Geoda software is used to establish the geographic distance spatial weight matrix, which is based on the latitude and longitude of the geographical location of the study provinces, $\sum_{i=1}^{n} WX_{it}$ represents the spatial lag term of the explanatory variables, $\sum_{i=1}^{n} WX_{it}$ is the spatial lag term of the explanatory variables, and ε_{it} refers to the spatial random error term.

As shown from Table 3, the coefficient ρ is positive, indicating that when the R&D subsidies and innovation of enterprises in neighboring regions improve, it has a driving effect on the improvement of the efficiency of R&D investment in neighboring regions, showing a positive spatial spillover. Since the spatial Durbin model (SDM) contains spatial lag variables, the interpretation of parameters becomes complicated. It is impossible to directly infer the influence effects of variables from the model regression coefficients, so this makes it especially necessary to decompose the spatial Durbin model for analysis to obtain the direct effect, indirect effect and total effect of R&D subsidies and enterprise innovation on regional economic development.

Table 2. Moran's index of economic growth (GDP per capita) by city and province

Year	Z	p-value*	Year	Z	p-value*
2010	2.822	0.002	2015	2.010	0.022
2011	2.722	0.003	2016	2.095	0.018
2012	2.527	0.006	2017	2.289	0.011
2013	2.368	0.009	2018	2.251	0.012
2014	2.154	0.016	2019	2.279	0.011

Table 3. Spillover effects of R&D subsidies and firm innovation

VARIABLES	Main	std
lnapply	0.136***	0.00
lnk	-0.042***	0.01
lnl	0.086***	0.00
lnsub	0.053***	0.00
Wlnapply	-0.077**	0.04
Wlnk	-0.086**	0.01
Wlnl	-0.035	0.39
Wlnsub	0.054*	0.08
ρ	0.129*	0.07
N	280	
R^2	0.573	
Number of City	28	

The spatial Durbin model decomposes the total effect of the interaction between variables mainly through the partial differential equation. The decomposition of the direct effect includes the initial effect and the feedback effect, where the initial effect is the change in the explanatory variables of a region brought about by the change in the explanatory variables of that region, and the feedback effect is when the change in the explanatory variables of a region brings about the change in the explanatory variables of neighboring regions, which in turn is fed back to that region through various channels of influence, thus leading to the change in the explanatory variables of that region. The indirect effect, also known as the spillover effect, is a measure of the effect of changes in the explanatory variables in one region on the explanatory variables in all other regions.

Table 4 is the decomposition result of the spatial Durbin model, from which we can find that the four different explanatory variables are significant at the 1% level. The coefficient of the direct effect of enterprise patent application is 0.135, indicating that each unit increase in enterprise R&D innovation output will lead to 0.135 units of local economic growth. While the coefficient of its indirect effect is negative and insignificant, which indicates that the increase in innovation output of SMEs in a region will increase the economic growth of the region to a certain extent. At the same time, it will have a

certain crowding-out effect on the economy of other regions. This is because SMEs with higher R&D and innovation capacity usually have a higher ability to attract foreign investment and scientific and technological talents, thus developing and growing the economic development of the region.

Measure the variable of R&D expenditure of firm innovation input, whether direct effect or indirect effect, does not promote the regional economic development level. The reason may be that most entrepreneurial enterprises are concentratedintheeasternpartof China,wherethecompetitivepressure is relatively high. Some enterprises have the phenomenon of *Free riding*, which is an enterprise increase independent R&D investment, other enterprises in the corresponding region will choose to imitate its R&D to increase their profits. This phenomenon will affecttheR&Dinvestmentoftheenterprisethroughthe feedbackmechanism of direct effect, which will have a certain inhibitory effect on the economic development of the region. The indirect effect is that the R&D and innovation activities of enterprises will lead to the flow of production factors and increase the competitiveness of products, thus negatively affecting the economy of other regions.

The direct effect of the number of R&D personnel is significantly positive, while the indirect effect is negative and insignificant, indicating that the level of R&D personnel labor in the region has a certain degree of promoting effect on the economic development of the region, while it has a certain degree of hindering effect on the economic development of other regions. The reason for this may be that human capital is relatively limited, along with the flow of R&D personnel to a certain region other regions will be correspondingly reduced, which will lead to a certain increase in the level of economic development of talent inflow areas and a corresponding decrease in the level of economic development of talent outflow areas.

The coefficient of the direct effect of the intensity of government R&D subsidies is 0.055, indicating that each unit increase in government R&D subsidies to SMEs will drive 0.055 units of economic growth in the region. While the coefficient of its indirect effect is 0.067, which is slightly larger than the direct effect, indicating that government R&D subsidies not only have a catalytic effect on local economic development, but also have a more significant spillover effect.

Table 4. Decomposition of effects based on the spatial Durbin model

VARIABLES	(1) LR_Direct	(2) LR_Indirect	(3) LR_Total
lnapply	0.135***	-0.066	0.070
std	(0.00)	(0.13)	(0.19)
lnk	-0.045***	-0.102***	-0.147***
std	(0.00)	(0.01)	(0.00)
lnl	0.087***	-0.027	0.060
std	(0.00)	(0.56)	(0.28)
lnsub	0.055***	0.067*	0.122***
std	(0.00)	(0.05)	(0.00)

5 Conclusions and Policy Recommendations

For the spillover analysis, we first conducted Moran's I test, and the results showed that there is spatial autocorrelation between R&D innovation of SMEs and government R&D subsidies among provincial regions in China. For model selection, we did the LM test, Wald test, and LR test, and finally selected the spatial Durbin model for analysis. The spatial weight matrix of distances was established in Geoda software using the geographical location latitude and longitude of each province, and the spatial spillover analysis was performed using STATA16 software. Through the estimation of the model and the analysis of the empirical results, the following conclusions are mainly obtained, regarding that government R&D subsidies for SMEs can not only promote the local economic development level, but also have a certain promotion effect on the economic development of other regions. The economic spillover to the surrounding regions is slightly larger than the economic promotion to the region. For the aspect of R&D innovation of SMEs, both the innovation output and R&D capital of enterprises have a significant positive spatial correlation to the local economic growth, while both show a certain inhibitory effect on the economic development of the surrounding areas.

Based on the above findings, this paper makes the following recommendations.

First, to fully promote local economic development, we should give full play to the government's leading demonstration role in SME R&D and actively utilize the spatial spillover effect that exists in the region. Increase the government's role in supporting SMEs, and can use the government's R&D subsidies for SMEs to stimulate local economic development. In contrast, it can similarly stimulate the economic growth of other surrounding areas. Second, actively build an innovative talent pool and further strengthen the training of research talents. Innovation is the first productive force, and innovative talents are one of the necessary elements for innovation. Local governments need to bring in talents from various fields, pay more attention to and support young researchers and improve policies for high talents if they want to vigorously develop innovative enterprises and make the economy of the region grow rapidly. Thirdly, since there is the phenomenon of *Free riding* in enterprise R&D innovation, enterprises should actively and consciously set up R&D barriers for their own independent R&D. Local governments should also increase the supervision and audit of enterprise patent applications and licenses. So that to achieve the goal of promoting enterprises to actively conduct independent R&D.

References

1. NationalBureauof Statistics,Ministry of ScienceandTechnology, Ministry of Finance. 2019 National Science and Technology Funding Investment Statist Bulletin [N]. China Information News, 2020-08-28(002).
2. Chen, J, Heng, C.S, Tan, B. C.Y and Lin, Z, The Distinct Signaling Effects of R&D Subsidy and Non-R&D Subsidy on IPO Performance of IT Entrepreneurial Firms in China[J]. Research Policy, 2018, vol. 47, pp. 108-120.
3. Junmei, Y, Research on the influence of innovation policy on innovation behavior of SMEs [D]. Huaqiao University,2020.

4. Baoping, R, Han, G, Jie, W et al., Report on the quality of China's economic growth [M]. Beijing:China Economic Press, 2019.
5. Qilin, M, Jiayun, X, The impact of government subsidies on firms' new product innovation--a perspective based on the 'moderate interval' of subsidy intensity[J]. China Industrial Economics, 2015, no. 06, pp. 94-107.
6. Chen, D, Yi, L, A comparative analysis of the impact of tax incentives and financial subsidies on corporate R&D [J]. Economic Science, 2008, no. 03, pp, 79-83.
7. Shu, L, Spatial spillover effects of science and technology innovation and regional economic growth[J]. Technology Economics and Management Research,2021, no. 06, pp. 25-30.
8. Xiongfeng, P, Bowei, A, Yang, M, Study on the spatial spillover effect of technological innovation between regions in China[J]. Operations Research and Management, 2019, vol. 28, no. 07, pp. 118-124.
9. Yang, Z, Yongguan, Z, Spatial dependence of corporate R&D investment-analysis based on spatial Durbin model[J]. Journal of Hebei University (Philosophy and Social Science Edition), 2018, vol. 43, no. 05, pp. 97-104.
10. Lanyun, X, Spatial econometric analysis of the role of R&D investment on economic growth pathways in Chinese provinces[J]. China Soft Science, 2013, no. 09, pp. 37-47.