Simulation of the influence of Guangdong-Hong Kong-Macao Greater Bay Area financial agglomeration on the technological innovation efficiency of high-tech enterprises based on SDM model

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ABSTRACT

How to build a collaborative mechanism of scientific and technological innovation and development in Guangdong-Hong Kong-Macao Greater Bay Area (abbreviation: the Greater Bay Area(GBA)) is undoubtedly an important link in building a world-class scientific and technological innovation center. Based on the panel data of 11 cities in GBA from 2012 to 2020, this paper empirically tests the influence of GBA financial agglomeration on the technological innovation efficiency of high-tech enterprises by using SDM(Spatial Dubin Model) model, starting from the innovative effect of financial agglomeration and considering two weight matrices of geographical distance and economic distance. The research results show that the regression results of GBA's SDM model show that the autocorrelation coefficients under 0-1 adjacency weight matrix and geo-economic distance weight matrix both exceed the significance levels of 1% and 10%, which shows that there is obvious correlation between the technical development efficiency of GBA's high-tech industries, but they are not independent of each other. The level of economic development in different regions and stages is quite different. The results show that, at the significant level of 1%, financial agglomeration has a greater role in promoting the efficiency of technological innovation.

Keywords: SDM model; Guangdong-Hong Kong-Macao Greater Bay Area; Financial agglomeration; Technological innovation efficiency

1. INTRODUCTION

With the deepening of reform and opening up, the proportion of primary industry in China has dropped significantly, the secondary industry has become the leading force to stimulate economic growth, and the tertiary industry has developed steadily. With the gradual promotion and implementation of the planning outline, the industrial integration and financial intercommunication among cities in Guangdong-Hong Kong-Macao Greater Bay Area (abbreviation: the Greater Bay Area(GBA)) will be further deepened, so as to give full play to their respective industrial advantages and achieve coordinated development. In the field of GBA, how to establish a coordination mechanism of scientific research innovation and development with GBA as the main body is of great significance for building a world scientific and technological innovation center with GBA as the main body[1].

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Seventh International Conference on Mechatronics and Intelligent Robotics (ICMIR 2023), edited by Srikanta Patnaik, Tao Shen, Proc. of SPIE Vol. 12779, 127791N · © 2023 SPIE · 0277-786X · Published under a Creative Commons Attribution CC-BY 3.0 License · doi: 10.1117/12.2689427

Technological innovation is a process of continuous improvement, and the standard for measuring innovation results is the input-output ratio, that is, efficiency. Therefore, efficiency measurement is a very critical issue, which should not only be supported by feasible data, but also reflect the real situation and provide direction guidance for improving efficiency [2-3]. Literature [4] takes the photovoltaic industry as an example, divides the samples into three different types according to the product and business content, and deeply analyzes the relationship among resource allocation efficiency, technological innovation efficiency and capacity utilization rate. Literature [4] uses DEA-CCR model to evaluate and analyze the technical efficiency of high-tech industries. Literature [5] uses SFA method to measure the innovation efficiency of China's financial service industry, and discusses the relationship between financial agglomeration and innovation efficiency of financial service industry. It is found that the influence of financial agglomeration on innovation efficiency of financial service industry is nonlinear. Literature [6] based on the intermediary effect, using the inter-provincial data in China, shows that financial agglomeration is guided by technological innovation, which accelerates the construction, adjustment and upgrading of industries in the region, and shows regular regional differences. Literature [7] studies the effect of financial agglomeration on the development of China's high-tech industry through the production function model, and finds that the bank agglomeration level is higher than the insurance agglomeration level, which has the most significant promotion effect on China's high-tech industry.

On the one hand, thus promoting technological innovation; On the other hand, when financial agglomeration develops to a certain extent, problems such as congestion and efficiency loss caused by excessive competition in the agglomeration area have a spatial reverse crowding-out effect on technological innovation [8]. The concentration of financial resources in GBA core cities is high, and it coincides with the concentration of regional science and education resources and the inclined direction of government R&D investment to a certain extent. This study takes 11 cities in GBA as the research object, and takes the data of 11 cities from 2012 to 2020 as the sample. Using SDM(Spatial Dubin Model) and the spatial weighting matrix of two dimensions of geography and economy, this paper empirically tests the influence of GBA financial agglomeration on the technological innovation efficiency of high-tech enterprises. Finally, the relevant conclusions are drawn, and some suggestions are put forward to improve the efficiency of GBA financial agglomeration on two-stage technological innovation in high-tech industries.

2. RESEARCH METHOD

2.1 Variable selection and data source

When at the forefront, the less investment in technology development, the more output. Only by getting higher output through relatively low investment in technological transformation can we achieve high efficiency in technological transformation, and get greater commercial value and innovation returns, which is the common pursuit of the whole industry. Financial agglomeration can further serve and support technological innovation activities by relying on the functions of the financial system itself. If the financial industry wants to play these functions, it is inseparable from improving its own operating efficiency.

The basic function of financial sector to mobilize savings plays a key role in economic growth, mainly manifested in the expansion of credit scale. Banks have obvious advantages in this function and are dominant in the financial system [9]. In this process, with the emergence of emerging industries or some core technologies of traditional industries at the forefront of world technology, the real economy has the need to avoid and spread risks, the capital market has begun to develop rapidly, and the function of financial system to avoid and spread risks has gradually taken shape; Therefore, the process of financial development from the basic function of mobilizing savings to the core function of allocating capital, and then to the derivative function of dispersing risks plays a leading role, is also the process of upgrading the financial level, and its deepening result is the dynamic evolution from financial quantitative growth to quality improvement.

Financial agglomeration indicators: This paper uses the location entropy method to measure the indicators:

FA :Financial industry agglomeration;

BA :Banking agglomeration;

SA :Securities industry agglomeration;

IA :Insurance industry agglomeration;

FVA :Development level of financial industry;

HSD :The development level of the banking industry;

SMV :Development of securities industry;

PMI :Development level of insurance industry.

Index of innovation efficiency of high-tech industry: This paper uses data envelopment method to measure the innovation efficiency TIE of high-tech industry in China. In this paper, the input-output system is constructed when measuring the innovation efficiency of high-tech industries [10-11].

Control variables: Ranging from macro-environment and market environment to enterprises themselves. Such as enterprise scale, government support and market. Drawing lessons from the existing research, this paper finally determines the following two influencing factors as control variables, namely, the regional economic level GDP as control variable 1 and the foreign investment amount FDI as control variable 2.

The sample of this paper is the relevant data of 11 cities in GBA. This paper adopts a two-stage SDM model that matches the chain process of innovation activities. At the same time, considering the time lag of innovation activities, this paper sets a lag period for the efficiency of technological innovation, and selects two years as the lag period, that is, from initial input to intermediate output to final output, with an interval of one year. Therefore, the time for capital investment and manpower investment in technological innovation is 2010-2018, and the time for data of knowledge output and economic output is 2012-2020. Therefore, 2012-2020 is chosen as the time span for research.

2.2 Model construction

The panel data is analyzed by multiple regression. The models are as follows (1) and (2), in which all variables are logarithmically processed. At the same time, considering the lag of input and output, the lag period is 2 years, that is, the initial input index is t period, the intermediate output is $t+1$ period, and the final output is $t+2$ period.

Model 1:

$$TIE_{it} = \gamma_0 + \gamma_1 FVA_{it} + \gamma_2 GDP_{it} + \gamma_3 FDI_{it} + \varepsilon_{it} \tag{1}$$

Model 2:

$$TIE_{it} = \beta_0 + \beta_1 BA_{it} + \beta_2 SA_{it} + \beta_3 IA_{it} + \beta_4 GDP_{it} + \beta_5 FDI_{it} + \varepsilon_{it} \tag{2}$$

Where subscript i stands for region, subscript t stands for year, γ, β stands for parameter to be estimated, and ε stands for error term. Model (1) is used to investigate the influence of financial agglomeration on the innovation efficiency of high-tech enterprises, and model (2) is used to analyze the influence of the respective agglomeration of banks, securities, insurance and venture capital on the innovation efficiency of high-tech enterprises.

The collection of enterprises constitutes an industry that produces the same type of products or provides the same type of services, and the innovative behavior of enterprises also reflects the characteristics of the industry, while the characteristics of market structure and market demand are important factors that affect the innovative behavior of enterprises. Because of the externality and uncertainty of innovation investment, in theory, the government subsidy can overcome the market failure, and governments all over the world have adopted innovative incentives or policies to guide enterprises to engage in innovation activities. The results also show that both tax relief and government financial subsidies have played a positive role in promoting the innovation investment level of enterprises.

When there is a difference in the cost of using external funds and internal funds, it is considered that there is a capital-knocking constraint. If the gap between internal and external capital costs is large, the degree of financing constraint will be greater. The special nature of innovative investment, agency conflict and information asymmetry are the root causes of financing constraints [12]. When analyzing the spatial effect, it is impossible to judge the most suitable spatial regression model intuitively, so statistical test should be carried out to select the appropriate spatial panel model. LM test can't identify the applicability of SDM, so Wald test and LR test can be carried out according to Burridge's test criterion to determine whether SDM can be simplified to SLM or SEM model. The specific form of the SDM model established in this paper is shown in the following formula:

$$TIE_{it} = \alpha_0 + \rho TIE_{it} + \alpha_1 BA_{it} + \alpha_2 SA_{it} + \alpha_3 IA_{it} + \alpha_4 FA_{it} + \alpha_5 GDP_{it} + \alpha_6 FDI_{it} + \theta_1 FVA_{it} + \theta_2 HSD_{it} + \theta_3 SMV_{it} + \theta_4 PMI_{it} + \mu_i + v_t + \varepsilon_{it} \quad (3)$$

Among them, i,t represents the region and time respectively, ρ is the lag coefficient of spatial regression of the explained variable technology development efficiency, and μ_i corresponds to the spatial effect; v_t corresponds to the time effect; ε_{it} is a random error term.

3. RESULT ANALYSIS

3.1 Statistical description of samples

The data used in this paper are panel data. From the descriptive statistics of various data of 11 cities in GBA (Table 1), it can be seen that the average *GDP* growth rate is 11.1768, the minimum is -17.0121, the maximum is 28.5394, and the standard deviation is 7.7988, which shows that the economic development in different regions is very different in different periods. The maximum and minimum *FA* are 6.6325 and 0.0224, respectively. The range of other variables is also very large, which shows that the financial development and economic growth in GBA are unbalanced, and some cities are far ahead of other cities in terms of financial scale, opening up and human capital investment.

Table 1. Statistical description of samples

Variable	Maximum	Minimum	mean value	standard deviation
TIE	1.0000	0.1128	0.3114	1.557
FA	6.6325	0.0224	0.5474	0.3261
BA	5.0109	0.1551	1.2306	1.7467
SA	46.3236	0.1047	1.1612	1.975
IA	10.7707	0.1289	0.1655	1.9774
GDP	28.5394	-17.0121	11.1768	7.7988
FDI	0.3838	0.2208	1.0568	3.0666

3.2 SDM model regression results

Because the SDM model contains the spatial lag term of the explained variables, OLS estimation is prone to result bias. In order to ensure the accuracy of the regression results, this paper adopts maximum likelihood estimation method for analysis, and the specific regression results are shown in Table 2.

Table 2. SDM model estimation results

Variable	0-1 adjacency		Geographical and economic distance	
	coefficient	T statistics	coefficient	T statistics
TIE	0.0024***	-0.9314	0.0033***	1.0403
FA	0.0013	0.4669	-0.0038	-0.0227
BA	-0.00151**	-2.9491	-0.00179	-2.2766
SA	-0.0013**	-1.8867	0.0058***	-2.9435
IA	-0.0044***	0.3823	0.0176	0.8633
GDP	-0.0026***	-2.7984	-0.0039**	-0.5887
FDI	0.00125***	-1.5697	-0.0037***	0.3794
FVA	-0.0041**	0.8582	0.0027***	-2.1167

HSD	0.0021	-3.0082	0.0004***	-1.3758
SMV	-0.0009***	-1.3242	-0.0011***	0.8905
PMI	0.0147	0.6615	0.0063	-1.8939
ρ	0.0107***	-0.5069	0.0102***	-0.9557
R^2	1.0000		1.0000	
Log-like	1000.8107		980.5257	

Note: *, * * and * * represent significant at 10%, 5% and 1% levels respectively.

The regression results of SDM model show that the spatial autocorrelation coefficient ρ passes the significance level of 1% and 10% under the 0-1 adjacency weight matrix and geo-economic distance weight matrix, which shows that there is obvious correlation between the technical development efficiency of GBA high-tech industries, but they are not independent of each other.

Under the two spatial weight matrices, financial aggregation has a positive effect on the efficiency of technology development, and both of them have been verified at 1% significance, which shows that financial aggregation can promote the efficiency of technology development to some extent.

3.3 Robustness test

In this paper, the robustness of model 1 is tested, the explained variables are replaced, and the technological innovation efficiency obtained by multiplying the comprehensive efficiency of the first stage and the second stage in the two-stage SDM model is used. The robustness test results of Model 1 are shown in Table 3:

Table 3. Robustness test result

Variable	**(1)**	**(2)**
FVA	0.336** (0.26)	0.217*** (2.77)
GDP	0.071* (1.68)	0.129* (1.72)
FDI	0.013* (1.79)	0.002 (0.16)
Constant	-0.638*** (-7.24)	-0.102 (-1.136)
Observations	170	140
R^2	0.336	0.287

It can be found that the regression results of the two models are basically the same as those of the original model. Model 1 and Model 2 draw the conclusion that financial agglomeration can promote the technological innovation efficiency of high-tech enterprises at 1% significance level, and Model 1 also draws the same conclusion at 5% significance level.

4. SUGGESTION

4.1 Industry effect of coordinating financial aggregation

The single financial system structure makes the financing channels of technological innovation of high-tech enterprises single, mainly including bank loans, lack of equity, bond financing and other direct financing methods. At this time, financial aggregation has a negative squeezing effect on high-tech enterprises. Therefore, on the one hand, we should maintain the steady growth of the banking industry, carry out the shareholding system reform of the banking industry,

promote the improvement of banking performance, thus injecting new vitality into the real economy. At the same time, we should give full play to the government's policy advantages, attract securities companies, venture capital institutions and other institutions to enter industrial clusters, and constantly expand the scale and coverage of industrial clusters.

4.2 Improve GBA financial development and in-depth cooperation policies and regulations

There are differences in the distribution and allocation of financial resources in 11 cities in GBA, and each city is also different in the operation and management of financial institutions and the construction of financial market system. Therefore, we should first actively promote regional financial cooperation at the national level, build the framework and agreement of GBA financial cooperation, make the financial development in GBA have laws to follow, strengthen the breadth and depth of GBA financial industry in the open field, appropriately reduce the threshold and restrictions of mutual penetration of related financial enterprises in GBA, and improve the convenience of financing. In addition, the convergence and integration of financial laws and regulations in GBA should be strengthened, and a multi-level security system for financial industries, financial institutions and financial consumers should be formulated from top to bottom to improve the maturity and integration of GBA policies and regulations.

4.3 Strengthen the strategic cooperation of financial innovation within GBA with financial agglomeration as the medium

We will strengthen the strategic cooperation of financial innovation in GBA, finally, the coordinated development of financial product design and internet finance and other financial innovations will be achieved, and the purpose of improving the efficiency of financial innovation in GBA system will be achieved. On this basis, further deepen GBA's financing innovation strategy, and enriching financing business, and improve the efficiency of financing system. Pay attention to the spatial spillover characteristics, degree and effect of financial agglomeration in GBA, so as to guide the innovation of financial system, financial products and business and promote the coordinated development of financial industry.

5. CONCLUSION

The main conclusions are as follows: According to the descriptive statistics of GBA data, we can know that the average GDP growth rate is 11.1768, the minimum is -17.0121, the maximum is 28.5394, and the standard deviation is 7.7988, which shows that there are great differences in economic development between different regions and different periods. There are cases where individual cities are far ahead of other cities in terms of financial scale, opening up and human capital investment. The regression analysis of SDM model shows that the spatial autocorrelation coefficient ρ reaches 1% and 10% respectively under the 0-1 adjacency weight matrix and geo-economic distance weight matrix, which shows that the technical development efficiency of GBA high-tech industries has significant correlation and is not independent of each other.

ACKNOWLEDGMENTS

Major scientific research at the college level of Guangdong Construction Vocational and Technical College（ZD2020-07）

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