Population Agglomeration and Economic Growth in Guangdong-Hong Kong-Macao Greater Bay Area

-- An Empirical Study based on Spatial Dubin Model

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Abstract

Based on the panel data of 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area from 2008 to 2017, this paper constructs a spatial Dubin model to empirically analyze the direct impact and spatial spillover effects of population agglomeration in the Bay Area on economic growth. Research shows that: the degree of population agglomeration in each region of the Bay Area is quite different. In 2017, the population density location entropy stratification is obvious; the global Moran's I index of population density and per capita GDP of each city is positive and significant; population agglomeration has positive spatial spillover effect on economic growth, and the total effect is also positive and significant. At the same time, the economic growth of cities in the Bay Area also has a significant positive spillover effect. Therefore, in order to promote the economic growth and coordinated development of cities in the Guangdong-Hong Kong-Macao Greater Bay Area, the government needs to take relevant measures to reduce the imbalance of population density and give full play to the positive effect of population agglomeration on economic growth.

Keywords

Guangdong-Hong Kong-Macao Greater Bay Area, population agglomeration, economic growth, spatial Dubin model.

1. Introduction

On February 18, 2019, with the publication of the "Guangdong-Hong Kong-Macao Greater Bay Area Development Plan Outline" by the Central Committee of the Communist Party of China and the State Council, the economic development of the Guangdong-Hong Kong-Macao Greater Bay Area has become a hot spot of international concern. From the perspective of the urban structure of the Bay Area, it includes 9 cities in the Pearl River Delta, namely Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, and Zhaoqing, as well as China's Hong Kong Special Administrative Region and Macau Special Administrative Region. A total of 11 cities, referred to as the Guangdong-Hong Kong-Macao Greater Bay Area. Comparing the four major bay areas in the world in 2017, the Guangdong-Hong Kong-Macao Greater Bay Area has the largest area, covering an area of 56,500 square kilometers, with a permanent population of 69.57 million. The calculated population density ranks first among the four major bay areas, with approximately 1,231 people Per square kilometer, the GDP growth rate is also the fastest, as high as 7.9%, and the GDP growth rates of the San Francisco Bay Area, New York Bay Area and Tokyo Bay Area are 1.7%, 3.5% and 3.6% respectively.

The economic significance of the Guangdong-Hong Kong-Macao Greater Bay Area lies not only in its internal growth, but also a major mission of driving the overall economic development of our country. Therefore, we must pay attention to the coordinated development of its internal economy, optimize the resource allocation of the Bay Area, and maximize its overall benefits. And then drive the economic progress of the surrounding area and even the whole country.

The relationship between population agglomeration and economic growth has always been one of the research directions of economists. Foreign scholars generally believe that population agglomeration can promote economic growth. In 1965, Williamson showed that spatial agglomeration can significantly improve the efficiency of economic growth at the initial stage, but when it reaches a certain threshold, the impact of spatial agglomeration on economic development begins to decrease, and then has an inhibitory effect [1]. Later, many scholars have verified Williamson's view, such as the results of Brulhart and Sbergami [2]; Martin and Ottaviano combined endogenous growth with endogenous location theory for research. They believed that when the commuting cost is lower than the innovation benefit, the gathering of factors such as population promotes economic growth, and they concluded that geographic agglomeration and economic growth are mutually reinforcing processes [3]; Ciccone and Hall first put forward the idea of using population density to represent population agglomeration at the end of the 20th century, and then used data from the United States and Europe to conduct quantitative empirical studies and found that population density and economic growth have a certain relationship [4,5].

Domestic scholars have also done a lot of research on the relationship between population agglomeration and economic growth. For example, Xie Li et al. adopted a simple regression model and selected panel data of 36 countries from 1994 to 2004. The results showed that the economic growth of a country or region has an optimal degree of population agglomeration, and then the degree of regional economic growth can be maximized [6]; Wang Shengjin et al. used China's 2000-2015 provincial panel data as a sample, and conducted research based on the spatial quartile map, Moran index, and imbalance index methods. The results showed that China's population agglomeration and economic agglomeration have significant spatial consistency [7]; Chen Le et al. based on the construction land data of 35 cities from 2005 to 2013, using GMM dynamic panel estimation, found that the impact of population agglomeration on urban economic growth is spatially heterogeneous [8]; Zhiyong Wang used the systematic GMM method to conduct research based on the city-level panel data from 1989 to 2015, and verified the applicability of Williamson’s research results in China, that is, population agglomeration and economic growth present an inverted U-shaped curve, and found that the pattern of regional economic growth is different between regions and cities [9]; Wang Zhichu started from Lucas's endogenous economic growth model, using provincial panel data from 2004 to 2014, and found empirically that population agglomeration can significantly improve the level of regional economic development, and support population agglomeration has a positive effect on economic growth [10].

From the existing literature, many scholars use GMM model to analyze the relationship between population agglomeration and economic growth, but ignore the influence of geographical space. Although in recent years, with the development of spatial econometric statistics, scholars have studied many issues related to economic growth based on a spatial perspective, but few scholars have applied the models among them to study the effects of population agglomeration on economic growth. In addition, perhaps because the time proposed by the Guangdong-Hong Kong-Macao Greater Bay Area is not too long, there is no literature that systematically studies the relationship between population agglomeration and economic growth in the Bay Area based on a spatial perspective. Therefore, on the basis of previous studies, this paper attempts to introduce the spatial econometric model into the study of the Guangdong-Hong Kong-Macao Greater Bay Area. At the same time, it abandons the traditional spatial distance matrix and adopts the economic distance matrix which is more suitable for the current situation to carry out the spatial econometric analysis, so as to complete the supplementary work of studying the population agglomeration and economic growth of the Guangdong-Hong Kong-Macao Greater Bay Area.

2. Variable, Spatial Weight Matrix and Model

2.1. Variable Selection

Explained variable: GDP per capita. This paper selects the per capita GDP data of each city in the Guangdong-Hong Kong-Macao Greater Bay Area to measure the level of economic development in each region, expressed in PGDP.

Core explanatory variable: population density. According to the experience of previous scholars, the degree of population agglomeration can be measured by population density, that is, the number of permanent residents in each city at the end of the year divided by the land area, expressed by PD.

Other explanatory variables:

(1) Employees, expressed by TL. The total number of employees in each city is used to represent the input of labor factors.

(2) Investment rate, expressed by INV. Generally, the change of capital stock can be represented by the investment rate. In this paper, the ratio of fixed asset investment in each city to GDP is used to express this variable.

(3) Number of patents granted, expressed by TEC. Technological innovation has made a significant contribution to the economic growth of a region. Considering the different calibers of the nine cities in the Pearl River Delta and Hong Kong and Macau, as well as the availability of data, the number of patent grants is selected to represent technological innovation.

(4) Urbanization rate, expressed by UR, that is, the ratio of urban population to the total population, is used to measure the urbanization process of each city.

(5) Openness, expressed by OPEN. The degree of openness is used to measure the level of economic openness in various regions. It can be expressed by the degree of trade dependence, which is obtained by dividing the total import and export of goods by each city by GDP.

(6) Macro-control, expressed by GOV. Fiscal expenditure can be used to represent the degree of government intervention in the economy. Due to the differences in the size of cities, this paper uses the proportion of fiscal expenditure in GDP to express the index.

(7) Economic structure, expressed by TPR. The ratio of the added value of the tertiary industry in GDP of each city is used as the proxy index.

The data selected in this paper are the panel data of 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area from 2008 to 2017. The data are from China Statistical Yearbook, Guangdong statistical yearbook, Guangdong science and Technology Yearbook, Hong Kong Statistical Yearbook and Macao statistical yearbook, etc. First of all, the descriptive statistics of each variable can be found that due to the different dimensions of the indicators selected in this paper, it is not advisable to directly use the original data for modeling. In order to eliminate the influence of the dimensions between different variables, the logarithm method is used to normalize the data. After processing, the descriptive statistics of the variables are shown in Table 1.

Table 1: Descriptive statistical results of variables after taking the logarithm

Index	Mean	Standard Deviation	Minimum	maximum
PGDP (yuan)	11.45759	0.7393011	9.906184	13.21414
PD (person/km^2)	7.490911	1.251007	5.545177	9.971613
TL (ten thousand people)	5.622514	0.878822	3.478158	6.849374
INV (%)	3.479727	0.4372405	2.515274	4.262257
TEC (piece)	8.538472	1.91779	2.70805	11.45371
UR (%)	4.391487	0.2521482	3.712596	4.60517
OPEN (%)	4.474975	0.8426799	2.826722	5.903589
GOV (%)	2.431062	0.3539496	1.704748	3.12676
TPR (%)	3.941085	0.3322517	3.511545	4.567468

2.2. Setting of Spatial Weight Matrix

Each element in the spatial weight matrix represents the proximity of the regions in each location, thus reflecting the correlation between the spatial elements. There are many ways to set the spatial weight matrix, such as the most basic 0-1 adjacency matrix, the spatial distance weight matrix calculated according to the distance between geographical units, and the time distance weight matrix obtained by calculating the time consumed by the main traffic modes between the two places. Because the areas of the cities studied in this article are quite different, and the relationship between population agglomeration and economic growth is studied, the spatial weight matrix is set in the form of economic distance matrix. That is, the reciprocal of the absolute value of the GDP difference per capita between geographic units, where the element on the main diagonal is 0, and finally the matrix is row-standardized.

2.3. Model Construction

This paper constructs a spatial Dubin model to analyze the direct impact of population agglomeration in the Guangdong-Hong Kong-Macao Greater Bay Area on regional economic growth and spatial spillover effects, and conducts logarithmic processing of various variables. The spatial panel Dubin model is set as follows:

$$\begin{aligned}\ln PGDP_{it} &= \alpha + \rho W \ln PGDP_{it} + \beta_1 \ln PD_{it} + \beta_2 \ln TL_{it} + \beta_3 \ln INV_{it} + \beta_4 \ln TEC_{it} + \beta_5 \ln UR_{it} \\ &+ \beta_6 \ln OPEN_{it} + \beta_7 \ln GOV_{it} + \beta_8 \ln TPR_{it} + \theta WX_{it} + \varepsilon_{it} \qquad (1)\end{aligned}$$

Among them, i and t represent cities and years in the Guangdong-Hong Kong-Macao Greater Bay Area, respectively. ρ and θ represent the regression coefficients of the explained variable and the spatial lag of the explanatory variable, respectively. β_i (i=1, 2, 3, 4, 5, 6, 7, 8) represents the regression coefficient of each explanatory variable, W represents the spatial weight matrix, and ε_{it} represents the random error term.

3. Empirical Research

3.1. Population Agglomeration in the Guangdong-Hong Kong-Macao Greater Bay Area

First, calculate the degree of population agglomeration in each city in the Guangdong-Hong Kong-Macao Greater Bay Area. According to the research of Liu Ruiwen and other scholars [11], the degree of population agglomeration can be measured by calculating the location entropy of population density. The calculation formula is as follows:

$$PAD_i = \frac{P_i / P_n}{G_i / G_i} = \frac{P_i / G_i}{P_n / G_n} \tag{2}$$

Among them, PAD_i represents the degree of population agglomeration in area i, P_i represents the year-end permanent population of area i, P_n represents the total year-end permanent population of the Guangdong-Hong Kong-Macao Greater Bay Area, G_i represents the land area of area i, and G_n represents the land area of the entire Guangdong-Hong Kong-Macao Greater Bay Area. Here we select the relevant data of 2017 for calculation, and the result of location entropy is shown in Figure 1 below.

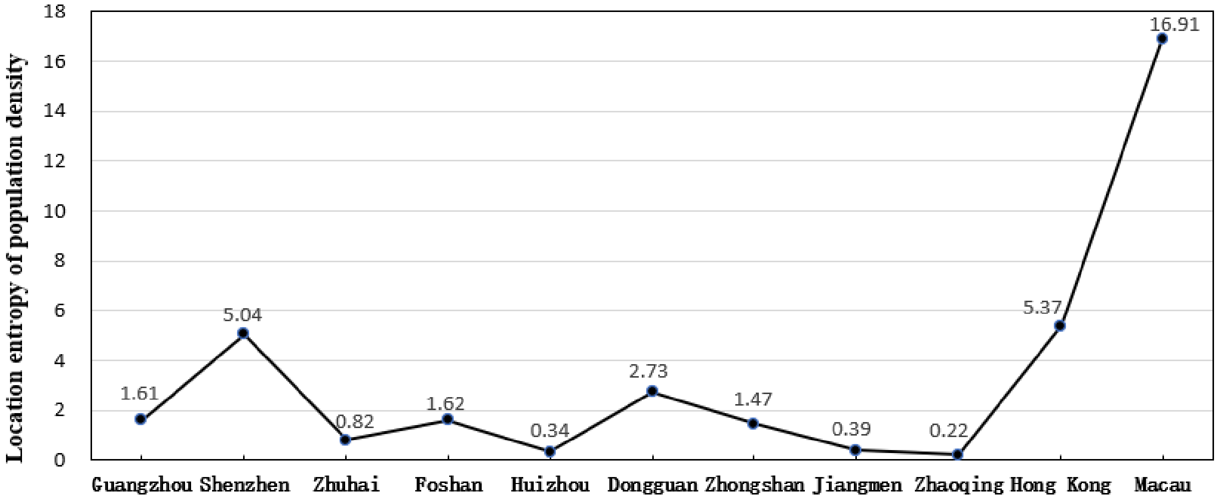

Figure 1: Population agglomeration in 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area in 2017

It can be seen from the figure that there is a certain gap in the population concentration of each city. The top three cities in terms of population concentration are Macau, Hong Kong and Shenzhen in order. Their values all exceed 5, and there are 4 cities with a value below 1. From low to high, they are Zhaoqing, Huizhou, Jiangmen, and Zhuhai. The population concentration values of the remaining four cities range from 1 to 5. On the whole, Macau, the city with the highest population density and location entropy, is almost 77 times that of Zhaoqing, which is the lowest. At the same time, the population density of core cities led by Hong Kong, Macau and Shenzhen is high. The degree of population agglomeration in the periphery of the city is relatively low, while the rest of the cities are in the middle.

3.2. Spatial Correlation Test

In this paper, Moran's I index is selected to test the spatial correlation of the cities in the Bay Area, and the Moran's I of population density and per capita GDP of the Guangdong-Hong Kong-Macao Greater Bay Area are calculated by using the economic distance matrix introduced above. The results are shown in Table 2 below. During the period 2008-2017, the Moran’s I index of population density and per capita GDP in each year was greater than 0, and both were significant at the 5% confidence level. This shows that the population agglomeration and economic growth of the Guangdong-Hong Kong-Macao Greater Bay Area are not independent of each other, but there is a positive spatial correlation, and provides a certain rationality for the following study on the spatial spillover effect between population agglomeration and economic growth in the Guangdong-Hong Kong-Macao Greater Bay Area by using the spatial Durbin model.

Table 2: Global Moran's I Index of Population Density and GDP Per Capita in Guangdong-Hong Kong-Macao Greater Bay Area

Year	Population density		GDP per capita	
	I value	P value	I value	P value
2008	0.062**	0.023	0.148**	0.022
2009	0.064**	0.027	0.141**	0.022
2010	0.065**	0.029	0.121**	0.020
2011	0.065**	0.029	0.105**	0.018
2012	0.063**	0.028	0.098**	0.016
2013	0.061**	0.027	0.089**	0.014
2014	0.058**	0.026	0.094**	0.014
2015	0.057**	0.026	0.135**	0.015
2016	0.057**	0.027	0.140**	0.015
2017	0.027**	0.028	0.130**	0.015

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

3.3. Analysis of Regression Results based on the Spatial Panel Dubin Model

Based on the panel data of 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area from 2008 to 2017, this paper uses the spatial Dubin model to empirically analyze the direct impact of population agglomeration on economic growth and spatial spillover effects. According to the Hansman test result, the P value is 0.9471, which is much greater than 0.05, so the null hypothesis cannot be rejected. The random effects model is selected for estimation. The regression results obtained are shown in Table 3 below.

Table 3: Estimation results of spatial panel Durbin model

Variable	Coefficient	Std. error	P value	Variable	Coefficient	Std. error	P value
lnpd	0.182***	0.059	0.002	Wx*lnpd	0.769***	0.275	0.005
lntl	0.185**	0.112	0.040	Wx*lntl	0.040	0.379	0.916
lninv	0.140**	0.062	0.024	Wx*lninv	0.318	0.237	0.180
lntec	0.057**	0.030	0.031	Wx*lntec	-0.262***	0.095	0.006
lnur	-0.008	0.248	0.976	Wx*lnur	-1.224*	0.697	0.079
lnopen	0.114**	0.050	0.021	Wx*lnopen	0.300	0.186	0.106
lngov	0.015	0.075	0.844	Wx*lngov	0.134	0.188	0.475
lntpr	0.298*	0.171	0.081	Wx*lntpr	0.782**	0.378	0.039
_cons	-6.300	3.872	0.104	Wx*lnpgdp	0.851***	0.245	0.001

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

From the estimation results, except for the urbanization rate and the ratio of fiscal expenditure to GDP, the coefficient estimates of other explanatory variables are significant. It is also found that the coefficient of population density and the spatial lag coefficient are both positive, 0.182 and 0.769 respectively, which are significant at the 1% confidence level. This shows that the economic growth of cities in the Guangdong-Hong Kong-Macao Greater Bay Area is not only positively affected by the local population agglomeration, but also by the population agglomeration of neighboring cities. In addition, the coefficient of the lag term of the explained variable is 0.851, which is significant at the 1% level, indicating that geographical factors have a significant positive impact on the economic growth of the Guangdong-Hong Kong-Macao Greater Bay Area. At the same time, the coefficient of determination of the model $R^2 = 0.9631$, reaching more than 90%, indicating that the model fits well. However, because the spatial lag term of the explained variables and the explanatory variables is added to the model, the estimated coefficients of each variable can not directly reflect its elastic coefficient, and can not correctly reflect the direct impact of population agglomeration variables on economic growth and spatial spillover effect in the Guangdong-Hong Kong-Macao Greater Bay Area. Therefore, it is necessary to take a partial differential method for the spatial Dubin model to obtain direct and indirect effects to continue to analyze the impact of variables on the economic growth of the Guangdong-Hong Kong-Macao Greater Bay Area. Since the main research object of this article is the population agglomeration and economic growth in the Guangdong-Hong Kong-Macao Greater Bay Area, only the direct, indirect and total effects of population density and GDP per capita are listed, as shown in Table 4 below.

Table 4: Direct influence and spatial spillover effect of spatial panel Durbin model

Variable	Direct effect	P value	Spillover effect	P value	Total effect	P value
lnpd	0.250***	0.008	1.213**	0.049	1.462**	0.034
lnpgdp	0.053	0.152	1.151***	0.000	1.204***	0.000

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

From Table 4 above, it can be seen that the direct impact of population agglomeration in the Guangdong-Hong Kong-Macao Greater Bay Area on economic growth is 0.250, which is significant at the 1% confidence level; the spatial spillover effect is 1.213, which is significant at the 5% confidence level; the total effect is 1.462, which is significant at the 5% confidence level. Specifically, the result shows that every 1% increase in the population density of a city in the Bay Area will increase the region's per capita GDP by 0.250%, and every 1% increase in the population density of neighboring cities will increase the region's per capita GDP by 1.213%, which is due to the geographical proximity, and the population of neighboring cities will flow to the local area, thus promoting the economic development of the region. In addition, as far as the economic development of the Bay Area itself is concerned, the spatial spillover effect of economic growth is 1.151, which is significant at the 1% confidence level, that is, every 1% increase in the per capita GDP of the neighboring areas will increase the per capita GDP of the region by 1.151%. At the same time, the total effect is also positive and significant at the 1% confidence level. These results indicate that the economic growth of cities in the Guangdong-Hong Kong-Macao Greater Bay Area is not independent, but will promote each other in neighboring regions, and then develop in the direction of economic coordination.

4. Conclusion and Enlightenment

This paper makes an empirical analysis of population agglomeration and economic growth in the Guangdong-Hong Kong-Macao Greater Bay Area by using spatial Durbin model. The results are as follows: First, the degree of population agglomeration varies greatly in each region of the Bay Area, and the population density in 2017 shows a large imbalance; Second, the population agglomeration and economic growth of the Bay Area are not independent of each other between regions, but have certain spatial agglomeration characteristics, and there is a positive spatial correlation. However, during the period 2008-2017, the Moran's I index of population density and per capita GDP declined, indicating that the population agglomeration and economic growth of the Bay Area have a decentralized trend; Third, population agglomeration in the Bay Area has a positive spatial spillover effect on economic growth, and the economic growth of various regions within the Bay Area has a significant positive spillover effect.

According to the above research conclusions, the population agglomeration in the Guangdong-Hong Kong-Macao Greater Bay Area has a positive direct impact on economic growth and spatial spillover effects, and the economic development of the Bay Area has significant positive spatial spillover effects and spatial dependence. Therefore, it is necessary for the government to take relevant measures to give full play to the positive economic effects of population agglomeration, and to realize the overall coordinated development of the economy of the Guangdong-Hong Kong-Macao Greater Bay Area. Some enlightenments are as follows:

First, improve the construction of urban infrastructure, service quality and convenience. The infrastructure of a city has a greater impact on the degree of population agglomeration, so its attractiveness can be used to increase the population size and thereby stimulate the city's economy. This requires scientific infrastructure planning, targeted investment in areas with low population agglomeration and high spatial spillover effects, strengthening the city's scientific and technological functions, promoting population mobility in cities in the Bay Area, and improving the city's optimality scale, and further efficiently realize the balanced and rapid development of the Bay Area.

Second, create more job opportunities and increase job diversity. The economic development of a city requires the support of various industries and enterprises, which is inseparable from the demand for labor. Conversely, areas with a higher degree of population agglomeration are more likely to attract population inflows due to faster economic growth and increased employment opportunities. At the same time, in the era of the rapid development of the Internet and the explosion of data and information, with the emergence of many new industries and enterprises, the demand and diversity of positions have also expanded. Therefore, in adhering to the concept of sustainable development, improve the efficiency of land use, actively promote the development of urban emerging industries, keep pace with the times, absorb talents, and then promote the overall economic growth of the bay area.

Third, improve the quality of education and teaching, increase the reserves of knowledge and talents. Urban education resources play an important role in population agglomeration. Rich and high-quality educational institutions can attract foreign population and retain local population. Many universities and research institutions are distributed in areas with high economic development level, which will undoubtedly improve the level of human capital and technological innovation ability of the region. Therefore, it is necessary to expand the proportion of education expenditures in fiscal expenditures and optimize the allocation of educational resources, so as to promote areas with low population concentration, cultivate more high-quality skilled talents for the Bay Area, and support the innovation and coordinated development of the urban economy.

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