Research on the Effects of high-speed railway on Innovation Agglomeration

- A Case Study of the Beijing-Shanghai high-speed railway

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Abstract. This paper analyzes the change of innovation agglomeration brought by high speed railway by analyzing the patent data from 2000 to 2014. Found that innovation is highly concentrated, and in the study of Beijing-Shanghai high-speed railway area, Gini coefficient up to 0.6837. After the operation of high-speed railway, the degree of innovation agglomeration has gradually weakened. The measurement of Moran's I index shows that the phenomenon of agglomeration is caused by the positive correlation of space. The dependence of innovation on spatial distance is decreased after the opening of the Beijing-Shanghai high-speed railway.

1. Introduction

The concept of Agglomeration comes from geography, referring to the rapid concentration phenomenon within a specific time in a specific area of resources, population. Innovation can bring healthy economic development, industrial upgrading to a country, and thus become an important driving force for social development. Schumpeter published "Theory of Economic Development" in 1912, the creation of a new economic development theory that innovation is the fundamental phenomenon of economic development. Since the innovation theory, research of innovation-related emerge. With the development of economic geography, spatial perspective of innovative research has become the focus.

China's economic development has made remarkable achievements, there is a clear trend of economic development： innovation has getting much more important in economic growth. Gerald Carlino and William R. Kerr（2014） reviewed academic research on the connections between agglomeration and innovation, finding that innovative activity tends to be more concentrated than industrial activity. Zhang Lihua and Lin Shan Lang (2010) selected five high-tech industries and five traditional manufacturing industries and calculated each industry's innovative location quotient and industrial location quotient of 30 provinces and cities in China mainland. Analysts believe that it is not comprehensive to explain the spatial concentration of innovation only through the perspective of the concentration of production.

With the rapid development of high-speed rail, studies on Agglomeration which high-speed rail brings is rising gradually. Ahlfeldt and Feddersen (2015) found that high-speed railway contributes 8.5% to GDP growth, based on the empirical analysis on economic development of Germany Cologne to Frankfurt high-speed railway line. Since the opening of high-speed railway, on one hand it enhances the city's economic agglomeration level along the high-speed rail and narrows internal differences, on the other hand it also declines the economic agglomeration level of non high speed rail cities and expand internal differences (Tan Chenglin, Zhong Zhaohui, 2014).

There are a lot of literature suggests that innovation has the characteristics of spatial agglomeration. But few linked analysis of innovative agglomeration and high-speed rail.

2. Research Methods

Currently, mainly basic indicators of single agglomeration level are Concentration Ration, Entropy Index, Herfindahl - Hirschman index, Space Gini Coefficient, EG index. These methods have their own advantages and disadvantages in measuring the level of agglomeration. CR is simple in calculation, but its result could easily affected by the selection of n value. The area with the largest location entropy of the measured variables is not necessarily the area with the highest concentration. Spatial Gini coefficient is simple and intuitive, but the results often contain false ingredients. Based on the reliability and feasibility of the data, this paper uses the spatial Gini coefficient to measure and analyze the agglomeration of innovation in space.

Although the agglomeration level is affected by the spatial correlation, Moran's I index is generally used in spatial statistics to test the spatial correlation and spatial difference between regions.

2.1 Spatial Gini coefficient

The Gini coefficient is an index create by Italy economist Gini based on Lorenz curve. It was originally used to measure the degree of inequality in the country or region. With the continuous development of research, principle and method of Lorenz curve and the Gini coefficient are applied to the area of industrial agglomeration. Li Huizhong, Wang Wenhai (2007) did a thorough study about structure and spatial distribution of service industry in the Yangtze River Delta by using the spatial Gini coefficient, study show that different service sector is not parallel development during structure evolution, and it's not homogeneous in space. Zhao Wei, Zhang Cui (2007) by calculating the spatial Gini coefficient of China's 20 manufacturing industry found that the degree of agglomeration in the industry and the degree of industry FDI penetration is proportional.

In order to measure the degree of innovation agglomeration before and after the operation of high-speed railway, this paper follows the method Krugman (1991) used to calculate the Gini coefficient of regional innovation output. The Gini coefficient is defined as follows:

$$G = \frac{1}{2N^2 x}\sum_{i=1}^{N}\sum_{j=1}^{N}\left|x_i - x_j\right| \tag{1}$$

Where N is the total number of regions, x is the average value of the variables. When all the provincial regional variables are equal, the location Gini coefficient is the smallest, and G=0; when the Gini coefficient is closer to 1, the degree of agglomeration of the measured variables is higher.

2.2 Moran index

Moran index is proposed by Moran, Moran's I x is an important indicator to measure the degree of similarity between spatially contiguous or adjacent areas. Moran's I is expressed as follows:

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \overline{x})(x_j - \overline{x})}{\sum_{i=1}^{n} i\sum_{j=1}^{n} j} \tag{2}$$

In the formula, x_i is the observed value; $\overline{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$; w_{ij} is the element of the spatial weight matrix of each region, and the structure principle is $w_{ij} = real\ distence\ between\ city(i) and\ city(j)$, therefore, W is a N * N matrix.

Standardized statistic Z is commonly used to test weather there is a spatial autocorrelation in the areas. Suppose there is no self correlation in the space (i.e. Z=0). The calculation formula for Z is:

$$Z = \frac{I - E(I)}{\sqrt{VAR(I)}} \tag{3}$$

When the Z value is significant and positive, the space has positive correlation, that is, similar observation value cluster in the region of space; when the Z value is significant and negative, space negative correlation, that is, similar observation value tends to be scattered; when the Z value is not significant, then observed values are independent, random distribution.

3. Measure of innovation agglomeration in Beijing-Shanghai high-speed railway area and Spatial correlation test

3.1 Data

Compared to other indicators, there are three distinct advantages of using patents to measure innovation output: First, patent statistics are available; second, the definition and meaning of patent is closely related to innovation; third, standard of patents is objective.

Beijing-Shanghai high-speed railway length of 1318km, it's the busiest passenger and freight transport corridors in China, running through Beijing, Tianjin, Shanghai, three municipalities, Hebei, Shandong, Anhui and Jiangsu provinces, linking two economic regions. This paper selects 62 prefecture level cities which relate to Beijing-Shanghai high-speed rail. Patent data comes from Statistical Yearbook of Science and Technology and the National Bureau of Statistics website.

3.2 Innovation agglomeration measurement and spatial autocorrelation test

Beijing-Shanghai high-speed railway officially opened to traffic on June 30, 2011. From 2005 to 2014, the G coefficients of the patent data calculation of the relevant cities of the Beijing-Shanghai high-speed railway are shown in figure 1.

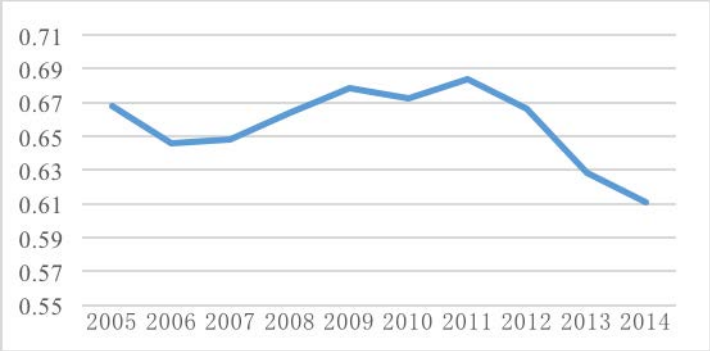

Fig. 1 G coefficient of innovation agglomeration in 2005-2014

The figure 1 shows that from 2005 to 2011, before the opening of the Beijing Shanghai high speed rail, G coefficient fluctuates between 0.6837~0.6462, its value is maintained at a higher level, the relevant cities showed a high degree of innovation agglomeration. But after 2011, the G coefficient decreased significantly. Innovation agglomeration phenomenon still exists, but the degree of agglomeration showed a downward trend than before the opening of the Beijing Shanghai high speed rail.

3.2 The spatial correlation of innovation agglomeration: the results of Moran index

In order to test whether the aggregation of innovation occurs randomly or there is a specific distribution law, and whether the operation of the high-speed railway has an impact on the spatial correlation. Testing the Spatial correlation of innovation data. Calculated Moran's I values during years of 2005-2014, calculation and test results has shown in table 1.

Table 1 The Moran's I and its test of regional innovation

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Moran'I	0.2336	0.2763	0.3105	0.3113	0.3635	0.3994	0.4075	0.3770	0.3142	0.2505
Z-value	3.3063	3.8723	4.3261	4.3371	5.0289	5.5046	5.6116	5.2081	4.3748	3.5304

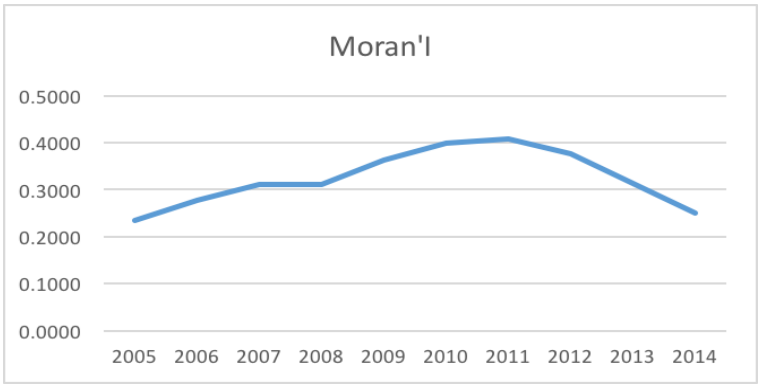

Fig. 2 The Moran's I between 2005-2014

As shown in Table 1 and Figure 2, the Moran's I between 2005 and 2014 is between 0.2336~0.4075, and the Z value has passed the statistical test of significant 5%. The results show that there is significant positive spatial dependence of the innovation cluster in the Beijing-Shanghai high-speed railway area. Cities with high level of innovation clusters with other cities with high level of innovation，cities with low level of innovation and other cities with low levels of innovation are close to each other.

In addition, it should be noted that the trend of Moran's I has also been significant changed. Since 2011, the Moran index has been falling continuously. The opening of the high-speed rail breaks the limit of the space distance, and brings weakening effect of the space dependence.

4.Analysis of innovation agglomeration effect

4.1Analysis of the relationship between high-speed railway and innovation agglomeration

The operation of high speed railway will greatly reduce the social cost of transportation, which will produce great social and economic benefits. As a kind of transportation infrastructure, high-speed railway has a great impact on the knowledge spillover and technology diffusion in the surrounding area. As to the research object of this paper, along the Beijing Shanghai high-speed railway area, and area accounted for 6.5% of the country, the population accounted for 1/4 of the country, GDP accounted for nearly 40% of the country, it’s the most active and potential area for China's economic development.

After the completion, journey time was reduced to 5 hours from Beijing to Shanghai, greatly improving the accessibility of the city along the railway, directly shorten the time and space distance between the cities. Daily average transport of passengers, from 134 thousand in 2011 to 312 thousand in 2015, an increase of 133%, as of the end of 2014, the number of employees in the Beijing-Shanghai high-speed railway area increased by about 27 million 880 thousand people. High speed railway makes the individuals with high level knowledge and technology get close to each other more easily, improve the availability of knowledge and technology, increase the knowledge exchange and diffusion, reduce the test cost, and promote the creation and production of new knowledge.

High speed railway, innovation agglomeration and economic and social development are closely related. Innovation is the inexhaustible source of economic growth, and innovation agglomeration accelerates the development of economy and society. GDP of the cities and this whole area along Beijing shanghai high-speed railway show rapidly growth. Among the cities, only Beijing, from 1 113.58 billion yuan in 2010 to 21330.8 billion yuan in 2014, an increase of more than 7217.22 billion yuan. GDP of whole area of Beijing shanghai high-speed railway increased 82598.9226 billion yuan.

Before the completion of the Beijing-Shanghai high-speed railway, along the railway innovation shows a high degree of concentration, and the degree of spatial dependence gradually increased. After analyzing the original data, innovations gather in the core cities such as Beijing Tianjin and shanghai. The completion of high-speed railway strengthens the contacts between core city and other cities. High-speed railway brings a series of changes like promoting talent exchanges, technology diffusion and improving the investment environment. When the innovation agglomeration in the core cities

along the high speed railway scales up to a certain level, then original positive effect of agglomeration mechanism gradually weakened, innovative elements diffusing from cities of innovation agglomeration to other cities gradually occupy the dominant position. Innovative knowledge highly dependent on the approaching geographical location before, the degree of dependence is gradually weakened under the influence of high speed railway.

Innovation agglomeration spillover from the core cities plays a very important role: on one hand, it can eliminate agglomeration diseconomy, optimize the scale of agglomeration; on the other hand, it can achieve new development, balance regional development and improve the level of industrial structure of the region. Modern economic competition is competition of innovation ability, innovation is increasingly showing a variety of possibilities, improving innovation ability become the decisive power of non-core cities to enhance its status.

5. Conclusions and suggestions

By analyzing the patent data from 2000 to 2014, this paper analyzes the change of innovation agglomeration brought by high speed railway. The main conclusions are as follows: innovation agglomeration does exist in the space, and in the study of the Beijing-Shanghai high-speed railway area, Gini coefficient up to 0.6837, which shows that innovation is highly concentrated. After the operation of the Beijing Shanghai high-speed railway, the degree of innovation agglomeration has gradually weakened, but still shows a high level of agglomeration. The measurement of Moran's I shows that the phenomenon of agglomeration is not random, which is caused by the positive correlation of space. At the same time also saw after the opening of the Beijing-Shanghai high-speed railway, the dependence of innovation on spatial distance is decreased.

What need to be explained is that the changes of innovation agglomeration depend on a number of important factors. The above analysis implies a suppressed premise that other factors outside the transportation infrastructure maintain a certain level. With the increase of high-speed railway operation time and the accumulation of data, the research of high-speed railway will lead to a lot of abundant and profound research results.

China has just entered the high-speed rail era not long. The study shows that the mechanisms of guidance, promotion, radiation, overflow and other positive mechanisms have become increasingly prominent. When policy makers make innovation policies, they need to open field of vision, fully considered the analysis and the use of innovation agglomeration, location advantages, knowledge spillover and spatial dependence, taking advantages of high speed railway, strengthening regional exchanges and expanding the scope of innovation diffusion to achieve the leap forward growth of innovation capability and economic strength.

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