Research on the Innovation Radiation of Shanghai Science and Technology Innovation Center to the Yangtze River Delta

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Abstract. By constructing a regional innovation capability evaluation index system, comprehensively measuring the innovation capabilities of cities in the Yangtze River Delta region, and using the modified gravity model to construct the basic spatial radiation framework for innovation in the Yangtze River Delta region, it is important for Shanghai Science and Technology Innovation Center and 26 core cities in the Yangtze River Delta region. The innovative radiation intensity was measured and analyzed, and further visualized analysis was made with the help of ArcGIS10.5 software. The results show that Shanghai Science and Technology Innovation Center is at the core of the innovation spatial structure of the Yangtze River Delta, but the scope of innovation radiation is relatively small; the spatial distribution of urban innovation in the Yangtze River Delta region is obviously unbalanced; the innovation environment is in the development of urban innovation. The role is increasingly obvious. Based on this, a number of suggestions for the Shanghai Science and Technology Innovation Center to lead the realization of the coordinated development of innovation in the Yangtze River Delta are put forward.

1. Introduction
With the development of the global economy entering the era of knowledge economy, innovation has become the core of driving economic growth. The interactive flow of innovation capital, innovation elements, and cross-border innovation cooperation have gradually formed a certain regional scope with the help of transportation integration and the Internet. The innovative relationship network [1]. After the integrated development of the Yangtze River Delta has become a national strategy, speeding up the implementation of innovative development concepts, building a modern innovative development system, and promoting the construction of innovative demonstration zones with international influence have become the focus of regional development. Shanghai has the world's influential economy, finance, trade, and shipping, and further proposes to build a scientific and technological innovation center, relying on the Yangtze River Delta as an important support, and using innovation radiation effects to lead the innovation and development of the Yangtze River Delta region.

2. Literature review
Urban agglomeration is the direct carrier of regional innovation and development, and its innovation growth trend has obvious spatial characteristics. The innovation and development of cities within the region have significant spatial correlation [2], and the agglomeration of innovation elements will...
generate radiation to a certain extent effect, driving the innovation and development of surrounding cities. In addition, geographical proximity can accelerate the radiation effect of innovation to a certain extent, making innovative interaction, cooperation, and learning more valuable and meaningful [3]. Bode [4], Griliches [5], Anselin [6] and other scholars are studying in universities, the impact of the innovation behavior of enterprises on regional innovation performance pointed out that geographical proximity has an important role in innovation. Subjects with geographical proximity can communicate and exchange innovative elements with the advantage of distance, and strengthen the exchange and learning of innovation resources, thereby Form industry and regional innovation cluster effects. At the same time, the coordination of cultural and institutional cognition under geographical proximity will also accelerate innovation radiation [7]. The improvement of urban innovation capabilities, on the one hand, comes from the development of innovation capital and innovation elements within the city; on the other hand, it will also be radiated and driven by other urban innovation elements and capital in the region [8]. Therefore, regional innovation radiation is affected by multiple factors such as the innovation ability of the innovation subject and the space distance [9], which is a complex and integrated process. Zhu Pengyi, Liu Donghua, and Huang Xinhuang [10] used the super-efficiency DEA window model combined with the Malmquist index to analyze the dynamic changes of the scientific and technological innovation efficiency of cities in Fujian Province when studying the radiation system of scientific and technological innovation among various cities in Fujian Province. Progress has always been a key constraint on the growth of urban total factor productivity. Wu Yuming and He Jiankun [11] pointed out that regional innovation has obvious heterogeneity and dependence in the spatial distribution pattern. Regional innovation is inseparable from the development of the local socio-economic environment. Geographic proximity and spatial differences are key factors affecting regional innovation. Zhang Huixuan, Liu Qing, and Li Gucai [12] used the spatial interaction model, selected the gravitational model to expand the measurement index, combined with the maximum gravitational line and the breaking point to measure and analyze the spatial pattern of innovative connections in 21 prefecture-level cities in Guangdong Province. The results show that regional cities the spatial pattern of innovation connections can easily show a "core-periphery" phenomenon in the development process, and the size and scope of innovation radiation will also change significantly over time. Zhang Zhanren [13] pointed out that China's innovation output generally presents a spatially positive correlation pattern, and the correlation intensity decreases with the increase of spatial distance, but the positive radiation effect of China's regional innovation development gradually increases over time. Feng Dexian, Jia Jing, and Qiao Xuning [14] used the analytic hierarchy process to study the radiation power index system of regional central cities, combined with the breaking point model to analyze the comprehensive radiation characteristics of innovation in Zhengzhou. For the impact, it is necessary to consider the combined effects of various factors, establish a comprehensive evaluation index system, and conduct an effective and reasonable measurement of the city's radiation capacity. Fang Dachun and Sun Mingyue [15] used the radiation field model to measure the urban influence when studying the urban influence of the Yangtze River Economic Belt. The results show that the influence scope of Shanghai is much larger than that of other core cities. The radiation influence of cities such as Wuhan is mainly concentrated in the surrounding cities; the radiation effect of the city is closely related to the distance and the quality of the city itself. The agglomeration function of the core city should be enhanced, and the diffusion and development of surrounding cities should be promoted through polarization.

Through combing the literature, we can see that the current empirical studies have all analyzed the urban innovation linkages, but there are still limitations in the quantitative analysis of urban innovation capabilities, regional innovation linkages patterns, and urban innovation radiation combined with actual models, which are mainly reflected in: First of all The indicator system of the current research model is too singular and cannot comprehensively reflect the city’s innovation capabilities from the macro and micro levels, resulting in a lack of accuracy in the calculated urban innovation capabilities, which affects the subsequent analysis of results; secondly, the innovation factors are different in the two innovation capabilities The flow between cities is directional. Capital and factors will flow to regions with strong innovation ability and superior innovation environment, resulting in different innovation radiation
between two cities with different innovation capabilities and the opposite direction. Most studies study the directional problem of the radiation of innovation elements is not considered, and the key application points of the model are ignored. In addition, most of the research data are time-point indicators [16], and the problem of innovation radiation changes during the passage of time is not considered. Analyzing the overall trend of innovation radiation from an angle, it is impossible to draw a scientific and reasonable conclusion. Therefore, by designing a comprehensive urban innovation comprehensive ability evaluation index system, this paper establishes the innovative radiation gravitational field model of the Shanghai Science and Technology Innovation Center, revises the definition of K value in the traditional gravity model, and uses the Shanghai Science and Technology Innovation Center as the field source to measure it. In 2012, 2015, and 2018, we used ArcGIS software to visually analyze the spatiotemporal evolution of the radiation value of the innovation radiation effects of cities in the Yangtze River Delta, and dynamically study the innovation radiation effects of the Shanghai Science and Technology Innovation Center from a spatial perspective. Promoting the coordinated development of innovation in the Yangtze River Delta region made relevant recommendations.

3. Urban innovation gravity model
In view of the deviation between the research on the urban innovation radiation model and the actual situation, this paper reconstructs the evaluation index system of urban innovation comprehensive ability, corrects the index limitation of the traditional model, redefines the innovation radiation coefficient in the model, distinguishes the innovation radiation direction between cities, and constructs a comprehensive urban innovation radiation model.

3.1. Theoretical basis of urban innovation gravity model
In the research on the innovation interaction between cities and cities, the gravity model is the most commonly used model for spatial innovation connections, and is widely used in the theoretical analysis of innovation spatial connections. The main theory of urban innovation gravity model is that with the continuous development of innovation, innovation elements and innovative capital are transferred and coordinated development between cities through various ways. There is spillover effect of innovation resources between the two cities. Similar to other social and economic phenomena, it is generally shown that cities with higher innovation development level have higher innovation development degree. If the innovation radiation effect of a city is relatively low, the technological innovation ability of a city will radiate around under the joint action of space and time [17]. According to the gravity model, the innovation effect of one city on other cities is directly proportional to the innovation quality of two cities, and inversely proportional to the geographical distance between cities. The basic form of the urban innovation gravity model is:

\[ R = K \frac{M_a M_b}{r^2} \]  

Among them, R represents the magnitude of the innovation gravity between the two cities, K represents the gravity coefficient, \(M_a\) and \(M_b\) represent the innovation quality of the two research target cities, a and b, respectively, r represents the geographic distance between the two cities, and the innovation gravity R It reflects the strength of the innovation connection between the two cities, and represents the joint effect of innovation formed between the two cities through the sharing of innovative resources, the exchange of innovative talents, and R&D investment activities.

On the basis of the basic innovation gravity model, according to the “Outline of the Yangtze River Delta Regional Integration Development Plan” approved by the State Council in 2019, the core area of the Yangtze River Delta urban agglomeration has been divided, and the city innovation gravity model of the Yangtze River Delta region has been established, and Shanghai is taken as the innovation radiation source to study its innovation radiation effect on 26 core cities in Jiangsu, Zhejiang and Anhui. In order to further study the change trend of the driving role of Shanghai’s innovation radiation in the Yangtze River Delta region, this paper uses the panel data of 27 cities in 2012, 2015 and 2018 to better show the
spatial and temporal changes of urban innovation radiation. The statistical data comes from the statistical yearbooks of various provinces and cities, the scientific and technological statistical yearbooks, and the statistical bulletins of national innovation and social development of each city, and the missing data is supplemented by interpolation.

3.2. Model modification
In order to enhance the fit and reliability of the model, the formula (1) is revised as follows:

3.2.1. Index correction. First of all, in terms of the quality of innovation in cities, most scholars use indicators such as population and GDP to measure the quality of innovation in cities. The indicator structure is relatively simple and cannot well reflect the overall innovation quality of the city. With the continuous improvement of living ability, the role of urban innovative human resources in the quality of urban innovation has become more and more obvious, and it has become another horse-drawn carriage driving innovation and development. In addition, the innovation environment and the living environment also have a great impact on the comprehensive ability of urban innovation. The quality of the environment will largely affect the inflow of innovative resources [18], which in turn affects the rapid improvement of the comprehensive ability of urban innovation. Therefore, on the basis of traditional indicators, this article selects six innovation input indicators: total number of R&D personnel, internal R&D expenditures, financial science and technology expenditures, three types of patent applications, the proportion of college students, and the actual use of foreign capital; the number of scientific papers, three The four innovation output indicators of patent authorization, technology contract turnover, and GDP per capita; the number of Internet users, the energy consumption of 10,000 yuan of GDP, the volume of passenger transportation, and the volume of freight transport throughout the society comprehensively evaluate the city's innovation capabilities.

Table 1. Comprehensive evaluation index system of innovation elements of science and technology innovation center

| Target layer | Criterion layer | Index layer | Company |
|--------------|----------------|-------------|---------|
| Input index  | Total R & D personnel | ten thousand people |
|              | Internal expenditure of R & D funds | RMB100mn |
|              | Financial expenditure on science and technology | RMB100mn |
|              | Three patent applications | piece |
|              | Proportion of College Students | % |
|              | actually utilized foreign capital | Million US dollars |
| Comprehensive capacity of urban innovation | Number of scientific papers | piece |
| Output indicators | Three patent grants | piece |
|               | Turnover of technical contract | RMB100mn |
|               | Per capita GDP | element |
| Innovation environment | Number of Internet users | ten thousand people |
|               | Energy consumption per 10000 yuan GDP | Tons of standard coal |
|               | Passenger volume of the whole society | ten thousand people |
|               | Freight volume of the whole society | 10000 tons |
3.2.2. Gravitational coefficient correction. Urban clusters within a certain range will cause convergence and complementarity between cities. The existence of complementary activities will cause obvious externalities to the innovation and development of cities, which will radiate and promote the innovation and development of surrounding cities [19]. The innovation radiation between cities is directional, which is specifically reflected in the differences in the innovation radiation effects produced by cities with different innovation levels and different innovation environments. Cities with strong innovation comprehensive capabilities will use their own concentrated innovation resources. Cities with weak comprehensive innovation capabilities have stronger innovation radiation effects. Therefore, the basic principle of urban innovation radiation conforms to the directional assumption of the modified gravity model. In the modified model, K is no longer a constant, and the gravitational coefficients $K_{ab}$ and $K_{ba}$ are not equal. With reference to Sun Jiujwen and Luo Biaoqiang [20], $K_{ab}$ in the economic radiation model is defined as the ratio of the urbanization rate of the two cities, using the three types of patent grants between the two cities ($x_a$, $x_b$) and the city’s per capita GDP ($y_a$, $y_b$). To comprehensively measure the size of the innovation gravity coefficient, that is

$$K_{ab} = \frac{x_a * y_a}{\sqrt{x_b * y_b}}$$

(2)

3.2.3. Innovative radiation distance correction. Since the time distance between the two cities will change over time, this article uses the highway mileage between provincial capitals as the basis to measure the innovation radiation distance between the two cities.

$$D_{ab}^Y = D^Y$$

(3)

In the formula, $D_{ab}^Y$ is the innovative radiation distance between the two cities, D is the geographic distance between the two cities, and γ represents the distance index, which is assigned a value of 1.5 [21].

3.3. Model principle and meaning

The revised gravity model expression is

$$R_{ab} = \frac{x_a * y_a}{\sqrt{x_b * y_b}} \sqrt{\frac{\sum_p x_{ap} M_{ap}^p \sum_q x_{bp} M_{bp}^q}{D_{ab}^Y}}$$

$$R_{ba} = \frac{x_b * y_b}{\sqrt{x_a * y_a}} \sqrt{\frac{\sum_p x_{ap} M_{ap}^p \sum_q x_{bp} M_{bp}^q}{D_{ab}^Y}}$$

(4)

(5)

Where: $R_{ab}$ and $R_{ba}$ represent the intensity of innovation radiation between cities; $\sum_p x_{ap} M_{ap}$ represents the innovation quality of city a, which reflects the comprehensive score of city a’s innovation capability, $x_{ap}$ represents the evaluation index system of city a’s innovation capability. The weight of the p-th indicator, $M_{ap}$ represents the score of the p-th indicator in the innovation ability evaluation index system of city a; $\sum_q x_{bp} M_{bp}^q$ represents the innovation quality of city b, reflecting the comprehensive score of city b’s innovation ability. Where $x_{bp}$ represents the weight of the qth index in the innovation capability evaluation index system of city b, $M_{bp}^q$ represents the score of the qth index in the innovation capability evaluation index system of city b; $D_{ab}^Y$ represents the difference between city a and city b Correct the distance.
4. Result analysis

4.1. Comprehensive innovation capabilities of Shanghai Science and Technology Innovation Center and site cities

Apply formula (3.3)—(3.7) to process the original data and obtain the weight of each indicator, and then substitute it into formula (4) to calculate the comprehensive innovation ability scores of 27 cities. The results are shown in Table 2.

| city                  | 2012year | 2015year | 2018year | city         | 2012year | 2015year | 2018year |
|-----------------------|----------|----------|----------|--------------|----------|----------|----------|
| Shanghai              | 15092.11 | 17240.92 | 23922.5  | Huzhou       | 4121.64  | 5025.25  | 6768.26  |
| Nanjing               | 10091.85 | 10118.72 | 14858.30 | Shaoxing     | 5263.40  | 8025.84  | 9064.44  |
| Wuxi                  | 13304.20 | 9951.19  | 11628.48 | Jinhua       | 5747.76  | 5402.24  | 6368.90  |
| Changzhou             | 7057.28  | 7402.27  | 8738.28  | Zhoushan     | 3826.90  | 4229.75  | 5156.99  |
| Suzhou                | 21129.76 | 15409.53 | 19321.52 | Taizhou      | 5315.02  | 5669.14  | 7440.06  |
| Nantong               | 8958.54  | 7199.73  | 8635.17  | Hefei        | 6213.21  | 7095.20  | 10494.03 |
| Yancheng              | 3842.97  | 4428.19  | 5993.45  | Chuzhou      | 2358.05  | 3169.36  | 3267.66  |
| Yangzhou              | 4348.09  | 5365.25  | 7700.42  | Maanshan     | 3098.10  | 3352.24  | 3663.29  |
| Zhenjiang             | 5295.99  | 5836.71  | 6648.29  | Wuhu         | 4579.01  | 4820.07  | 6399.48  |
| Taizhou               | 4723.46  | 6208.60  | 7054.05  | Xuancheng    | 2388.24  | 2436.04  | 2824.56  |
| Hangzhou              | 11050.62 | 11841.60 | 14361.11 | Tongling     | 3532.82  | 3185.40  | 2625.66  |
| Ningbo                | 12766.24 | 11434.72 | 13645.24 | Chizhou      | 1633.95  | 1923.54  | 2130.03  |
| Wenzhou               | 5779.88  | 6774.07  | 9036.32  | Anqing       | 1522.11  | 2567.12  | 2723.74  |
| Jiaxing               | 4663.40  | 6065.93  | 7592.14  |              |          |          |          |

According to the comprehensive evaluation index system of urban innovation, calculate the proportion of each innovation factor in the evaluation of innovation ability, and the score of urban innovation comprehensive ability is obtained by weighting. The higher the value, the stronger the comprehensive ability of urban innovation, and the city attracts innovation factors and innovation capital. The stronger the force, the weaker the radiation effect of innovation in surrounding cities, and the stronger the radiation effect of innovation in surrounding cities. As can be seen from the above table, Shanghai Science and Technology Innovation Center's comprehensive urban innovation capability score is significantly higher than other cities, which is consistent with the actual innovation status of Shanghai Science and Innovation Center. With the help of ArcGIS10.5, the spatial distribution map of the
comprehensive innovation capability of the urban agglomerations in the Yangtze River Delta is drawn (Figure 1).

![Spatial distribution map of comprehensive innovation capabilities of urban agglomerations in the Yangtze River Delta](image)

**Figure 1.** Spatial distribution map of comprehensive innovation capabilities of urban agglomerations in the Yangtze River Delta

On the whole, the comprehensive innovation capabilities of most cities in the Yangtze River Delta region have increased significantly. In 2015, the average growth rate of site cities’ comprehensive innovation capabilities was 3%, and the average growth rate of site cities’ comprehensive innovation capabilities in 2018 The growth rate of Shanghai Science and Technology Innovation Center as a field source was 14% in 2015 and 39% in 2018. The data can fully show the growth rate of Shanghai Science and Innovation Center, the ability to drive innovation and radiation. However, there is a large gap in the comprehensive innovation capability between cities. Innovation elements and innovation capital are mainly concentrated in core cities such as Shanghai and Suzhou, showing a clear core-periphery structure, which is not conducive to the improvement of the overall innovation capability of the region, and can not realize the balanced development of regional innovation.

4.2. *Shanghai Science and Technology Innovation Center and the correction of the urban innovation radiation coefficient of each site*

From equation (2), we can get the innovation radiation coefficient of Shanghai Science and Technology Innovation Center to each site of the Yangtze River Delta City Group. The weaker the innovation radiation is, affected by the innovation radiation effect of the field source city; the larger the coefficient, the stronger the dominant position of the field source city in the innovation radiation, and the larger the
urban development gap between the field point and the field source city, the innovation radiation effect. The stronger it is, the easier it is for the site city to receive the innovation radiation from the source city, and the stronger the innovation radiation effect.

Table 3. Innovation radiation coefficient of Shanghai Science and Technology Innovation Center to each site city

| city          | 2012 year | 2015 year | 2018 year | city          | 2012 year | 2015 year | 2018 year |
|---------------|-----------|-----------|-----------|---------------|-----------|-----------|-----------|
| Nanjing       | 1.60      | 1.37      | 1.36      | Huzhou        | 2.78      | 2.31      | 2.72      |
| WuXi          | 0.83      | 1.17      | 1.43      | Shaoxing      | 2.19      | 1.45      | 1.86      |
| Changzhou     | 1.80      | 1.61      | 1.89      | Jinhua        | 2.22      | 2.48      | 2.68      |
| Suzhou        | 0.62      | 0.86      | 0.97      | Zhoushan      | 7.29      | 4.81      | 7.08      |
| Nanjing       | 1.36      | 1.69      | 2.10      | Taizhou       | 2.71      | 2.32      | 2.45      |
| Yancheng      | 4.38      | 3.70      | 3.22      | Hefei         | 2.86      | 2.23      | 2.12      |
| Yangzhou      | 2.81      | 2.24      | 2.13      | Chuzhou       | 7.71      | 7.56      | 7.77      |
| Zhenjiang     | 2.28      | 2.00      | 2.53      | Maanshan      | 5.80      | 4.75      | 5.22      |
| Taizhou       | 2.86      | 2.43      | 2.71      | Wuhu          | 2.93      | 3.19      | 3.63      |
| Hangzhou      | 1.10      | 1.10      | 1.27      | Xuancheng     | 8.24      | 8.42      | 8.74      |
| Ningbo        | 0.93      | 1.15      | 1.45      | Tongling      | 5.53      | 6.75      | 10.28     |
| Wenzhou       | 2.51      | 2.14      | 2.25      | Chizhou       | 13.11     | 10.23     | 12.25     |
| Jiaxing       | 2.39      | 2.05      | 2.27      | Anqing        | 13.49     | 8.14      | 9.60      |

It can be seen from the data that the Shanghai Science and Technology Innovation Center has the weakest innovation radiation effect on Suzhou. Although after 2012, with the establishment of the Shanghai Science and Technology Innovation Community, its innovation radiation effect on surrounding cities has increased, but by the end of 2018, the innovation radiation coefficient for Suzhou was still less than 1, indicating that the innovation radiation effect of Suzhou receiving the Shanghai Science and Technology Innovation Center in 2012 was relatively weak. For the two cities of Ningbo and Wuxi, in 2012, Ningbo and Wuxi received a relatively low degree of innovation radiation effect from the Shanghai Science and Technology Innovation Center. The reason is that Ningbo and Wuxi’s overall urban development situation is better, and the government attaches great importance to innovation investment and R&D. expenditure, the survival pressure of the city is relatively small, and the per capita GDP is relatively high, resulting in a low innovation radiation coefficient. However, with the establishment and development of the Shanghai Science and Technology Innovation Center, its innovation radiation effect has been further enhanced, and the innovation radiation coefficient of Ningbo and Wuxi has been continuously improved. For other cities, the Shanghai Science and Technology Innovation Center has always maintained a high radiation status of innovation, and its innovation radiation capacity has shown an upward trend year by year. Through the continuous radiation of innovation, it will improve the comprehensive innovation capabilities of core cities in the Yangtze River Delta region and further realize the innovation in the Yangtze River Delta Coordinated development.

4.3. Radiation effect evaluation based on modified distance in Shanghai Science and Technology Innovation Center

According to formula (4), combining the comprehensive ability of urban innovation and the innovation radiation coefficient between cities, the innovation radiation effect value of Shanghai Science and Technology Innovation Center on each site city under the corrected distance is obtained. The results are shown in Table 4. The higher the score of innovation radiation effect, the greater the innovation leading role of Shanghai Science and Technology Innovation Center in the calculation year, and the stronger the innovation radiation effect of Shanghai Science and Technology Innovation Center.
Table 4. The scores of innovative radiation effects based on the modified distance of each city

| City   | 2012 Year    | 2015 Year    | 2018 Year    | City   | 2012 Year    | 2015 Year    | 2018 Year    |
|--------|--------------|--------------|--------------|--------|--------------|--------------|--------------|
| Nanjing | 47109.09     | 46321.11     | 93377.04     | Huzhou | 95885.2      | 111049.1     | 244946.7     |
| Wuxi    | 101833.50    | 122760.63    | 242024.33    | Shaoxing | 63457.05    | 73251.15     | 146837.84    |
| Changzhou | 81909.16    | 87883.72     | 169568.91    | Jinhua | 32430.21     | 38835.80     | 68952.58     |
| Suzhou  | 185918.06    | 214738.36    | 424251.51    | Zoushan | 86113.45     | 71695.90     | 178816.47    |
| Nantong | 129664.12    | 148527.63    | 306801.13    | Taizhou | 29894.45     | 31285.42     | 59590.92     |
| Yancheng | 47457.81     | 52790.92     | 86231.49     | Hefei   | 26700.85     | 27167.12     | 53017.52     |
| Yangzhou | 40808.12     | 45893.05     | 86869.05     | Chuzhou | 39506.06     | 59458.78     | 87484.69     |
| Zhenjiang | 45874.19    | 50698.34     | 101281.43    | Maanshan | 45891.56     | 46391.76     | 77365.11     |
| Taizhou  | 58070.29     | 74036.59     | 130086.21    | Wuhu    | 30895.81     | 40518.90     | 84859.95     |
| Hangzhou | 77802.89     | 95581.86     | 185204.57    | Xuancheng | 62385.84     | 74261.38     | 124052.39    |
| Ningbo  | 52259.49     | 66426.37     | 138197.59    | Tongling | 39329.82     | 49424.44     | 86159.73     |
| Wenzhou | 22225.46     | 25288.19     | 49290.54     | Chizhou | 36397.11     | 38177.67     | 70227.33     |
| Jiaxing | 173280.85    | 220469.39    | 425493.76    | Anqing  | 29369.23     | 34133.14     | 59294.11     |

It can be seen from Table 4 that over time, the innovation radiation effect of the Shanghai Science and Technology Innovation Center on the remaining 26 cities in the Yangtze River Delta has increased significantly. To support the development of high-tech enterprises, the ability to transform innovation achievements has been continuously improved, and the comprehensive innovation capabilities of the Shanghai Science and Technology Innovation Center have been continuously improved. From the perspective of refining the radiation path, the radiation effect range of the Shanghai Science and Technology Innovation Center based on time distance has increased from [22225.46, 185918.06] in 2012 to [25288.19, 220469.39] in 2015, and it has increased to [49290.54, 425493.76] in 2018. The data fully shows that the Shanghai Science and Technology Innovation Center's increased investment in innovation has significantly enhanced the innovation radiating effect of surrounding cities. Use ArcGIS10.5 to further draw a schematic diagram of the gravitational space of the Yangtze River Delta urban agglomeration receiving innovation (Figure 2).
Through analysis, it can be seen that Shanghai has a strong innovation radiation effect on Suzhou and Jiaxing. Based on the advantages of geographical location, Suzhou and Jiaxing can well receive the radiation of Shanghai’s innovation and establish an effective innovation connection path to develop their innovative industries. For Suzhou, although the innovation radiation coefficient with Shanghai is relatively small and the innovation radiation effect is weak, its own comprehensive urban innovation capability is relatively high, and it can have a synergistic development effect with Shanghai’s innovation elements and innovation capital. The radiation effect of innovation between cities has made up for its small innovation coefficient. For Jiaxing, compared with Suzhou, its comprehensive ability of urban innovation is low, and it is difficult to attract the inflow of innovation elements and innovation capital, but its innovation radiation coefficient is high, and it can well undertake the investment from the Shanghai Science and Technology Innovation Center. The radiation effect has made up for its lack of comprehensive urban innovation capabilities, and has enhanced the radiation attraction of Jiaxing and the Shanghai Science and Technology Innovation Center.

5. Conclusion and suggestion

5.1. Conclusion
1. Shanghai’s comprehensive innovation capability is in a leading position in the Yangtze River Delta region. As a national key innovation city, Shanghai attracts the influx of innovation elements by virtue
of its superior geographical location and good innovation environment, providing innovation elements and capital for the construction of Shanghai Science and Technology Innovation Center.

2. The innovation and development of the Yangtze River Delta region presents an obvious phenomenon of "core-periphery" polarization, and there are large differences in innovation capabilities between regions. Shanghai and Suzhou's comprehensive innovation capabilities are clearly ahead of other cities and belong to the core areas of innovation. The remaining cities have low comprehensive innovation capabilities. The gap between core and peripheral innovation capabilities has gradually expanded over time.

3. The comprehensive innovation ability of a city is affected by many factors, and it is difficult to use a certain indicator to evaluate it in detail. From the perspective of the development and changes of Suzhou's innovation capabilities, the innovation environment is playing an increasingly important role in the comprehensive ability of urban innovation. A good innovation environment has become a new catalyst for regional innovation development.

4. Suzhou and Jiaxing have the most obvious effect in the process of undertaking the innovation radiation of Shanghai, indicating that geographical proximity can enhance the innovation and development of cities to a certain extent; at the same time, the innovation radiation between cities will also be affected by the research subject's own innovation and development capabilities. Geographical environmental factors, the innovation ability of surrounding cities, the innovation ability of the city itself, and the degree of innovation radiation between cities determine the size of the regional innovation development potential.

5. Innovative development between cities is interactive. Affected by the city's own innovation development capabilities and the innovation environment, there are differences in the size and direction of innovation radiation between cities, which are manifested in different levels of attraction to innovation elements. Cities with strong innovation and development capabilities and a suitable innovation environment attract other cities' innovation factors and innovation capital inflows, creating an innovation agglomeration effect.

5.2. Suggestion
1. As the core city of innovation in the Yangtze River Delta, Shanghai should increase the investment of innovation elements and innovation capital, further enhance the innovation driving role of Shanghai Science and Technology Innovation Center, optimize its own innovation environment, improve comprehensive innovation capabilities, and expand its relationship with surrounding cities. The innovative connection of the company can better play the role of innovation radiation.

2. The improvement of urban innovation development capabilities will be accelerated by cities with strong innovation capabilities. By encouraging innovation cooperation and exchanges between cities within the region, corresponding policies are formulated to encourage cross-regional innovation cooperation, and promote the development of innovation elements and innovation capital. Integrate, increase the synergy of innovation, reduce the difference in innovation capabilities between the core and the periphery, and improve the overall regional comprehensive innovation capabilities to achieve the coordinated development of innovation in the Yangtze River Delta.

3. As an integral part of the innovation system in the Yangtze River Delta region, while actively doing a good job in innovation communication and exchanges with surrounding cities, we strive to improve our own comprehensive innovation capabilities in order to better undertake the innovation radiation from the Shanghai Science and Technology Innovation Center and build a sound innovation environment will increase R&D investment to attract more innovation elements and the inflow of innovation capital.

4. Improve the infrastructure construction between cities in the Yangtze River Delta region, remove obstacles to the circulation of internal innovation resources, encourage the cross-regional operation of innovative elements and innovative capital, implement corresponding policies to encourage the development of innovative industries, and form collaboration and mutual assistance with other
innovative cities Innovation relationship, jointly promote the maximum regional innovation performance.1.

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