Influencing Factors of Knowledge Cooperation in Urban Agglomeration on Yangtze River Delta from the Perspective of Innovation Network

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Abstract. Based on the perspective of innovation networks, an theoretical and empirical analysis of the influencing factors of the knowledge cooperation network of urban agglomeration on Yangtze River Delta (UA-YRD) in 2009-2013 and 2014-2018 was carried out using social network analysis. The analysis result shows that geographical distance, gap in the level of economic development, institutional proximity, gap in the level of scientific research output, and gap in the level of scientific research input are important factors affecting the knowledge cooperation network of UA-YRD, among which geographical distance, gap in the level of economic development and gap in the level of scientific research output have significant negative impacts on it, while institutional proximity and gap in the level of scientific research input have significant positive impacts on it. The analysis of this article will help to raise the level of knowledge cooperation in the Yangtze Delta, improve the efficiency of collaborative innovation and improve the integrated development system and mechanism, which will also drive the development of the UA-YRD to a great extent.

Keywords: Innovation Network Perspective, UA-YRD, Knowledge Cooperation Network, Influencing Factors

1. Introduction

Under the guidance of national policies, UA-YRD has taken the lead in entering a critical stage of transformation, upgrading, and innovative development. As an important form of innovation, knowledge cooperation in UA-YRD has distinct network characteristics, and there are problems such as irrational distribution of innovation resources, low innovation level, serious homogeneity, and weak urban innovation functions [1]. At the same time, with the progress of the times and with the development of science and technology, the factors affecting knowledge cooperation are becoming more and more complex. In order to improve the level of knowledge cooperation in UA-YRD, it is important to reveal the main factors affecting the knowledge cooperation network in UA-YRD.

In addition, the current academic circles pay less attention to the innovation and knowledge cooperation network of UA-YRD. Existing research involving the innovation of the Yangtze River Delta region focuses on the discussion of the spatial differences in innovation in the Yangtze River
Delta region [2]. The knowledge cooperation of UA-YRD is less discussed. In terms of research methods, there is a lack of innovative network analysis methods for research, and research on the influence factors of the knowledge cooperation network of UA-YRD, and the choice of research time is not large enough to analyze the collaborative innovation network of the UA-YRD. Therefore, this paper uses the social network analysis method to study the influencing factors of the knowledge cooperation network of UA-YRD in the two time periods of 2009-2013 and 2014-2018, which will provide a reference for improving the knowledge cooperation level of UA-YRD.

2. Theoretical Analysis of the Influencing Factors of Knowledge Cooperation Network of UA-YRD

In this paper, through the theoretical research and related literature of collaborative innovation and knowledge cooperation network, the influencing factors of the knowledge cooperation network of UA-YRD are preliminarily summarized into five aspects: geographical distance, gap in the level of economic development, institutional proximity, gap in the level of scientific research output and gap in the level of scientific research input, and put forward the following assumptions [3-5].

2.1. Geographical Distance

Geographical distance is the most concerned factor for scholars. Geographical proximity is not only conducive to the exchange and cooperation of knowledge, but also conducive to the formation of a good interpersonal relationship of knowledge cooperation. Knowledge cooperation within UA-YRD mostly occurs between cities or provinces that are geographically close to each other. Since 2000, although some achievements have been made in the development of traffic integration in the Yangtze River Delta, the degree of traffic development needs to be further improved. The coefficient of variation of railway and highway traffic network density is not optimistic. The former shows a downward trend as a whole. The latter has always been maintained at a low level. Therefore, the increase of geographical distance between cities in the Yangtze River Delta will inevitably lead to an increase in the cost of knowledge cooperation and exchange, which will have a negative impact on the knowledge cooperation between the two cities. Based on this, this paper puts forward the first research hypothesis:

\[ H1: \text{geographical distance has a negative impact on knowledge cooperation.} \]

2.2. Gap in the Level of Economic Development

The level of economic development is also an important factor affecting knowledge cooperation. The closer the level of economic development between the two cities is, the easier it is to produce cooperation (Yang Hongchang and Li Peng, 2017). According to the previous analysis, the knowledge cooperation of UA-YRD mostly occurs between cities with similar level of economic development or small gap. Such as Shanghai, Nanjing, Hangzhou, Wuxi, Wuhu, Hefei and other cities. Based on this, this paper puts forward the second research hypothesis:

\[ H2: \text{the gap in the level of economic development has a negative impact on knowledge cooperation.} \]

2.3. Institutional Proximity

The knowledge cooperation within UA-YRD mostly occurs between Shanghai and the provincial capitals of Nanjing, Hangzhou and Hefei, or between Wuhu and Wuxi, which have the same administrative level. It can be seen that the common or similar institutional environment is the prerequisite for cross-regional knowledge cooperation [6]. Based on this, this paper puts forward the third research hypothesis:

\[ H3: \text{institutional approach has a positive impact on knowledge cooperation.} \]

At the same time, this article draws lessons from the treatment method of Wang Zhongyan, and the specific formula of the system approaching is as follows:
2.4. Gap in the Level of Scientific Research Output
The level of scientific research output between cities is close enough for them to communicate and understand new knowledge, which will greatly save the cost of knowledge cooperation and improve the efficiency of communication between the two cities [7]. When the gap in the level of scientific research output is large, the knowledge development between cities is not at the same level, knowledge communication and exchange is difficult, the possibility of cooperation is less. Based on this, this paper puts forward the fourth research hypothesis:

H4: the gap in the level of scientific output has a negative effect on knowledge cooperation.

2.5. Gap in the Level of Scientific Research Input
When analyzing the gap in the level of scientific research input, we should consider not only the absolute quantity gap of R & D investment, but also the source of research funding [8]. From 2011 to 2017, the proportion of government investment is still relatively high and that of enterprises is relatively low in the Redd funds of UA-YRD. If only the absolute quantity gap of R & D investment level is considered, it may have a "negative" impact on knowledge cooperation, but combined with the sources of R & D funds, factor flow and price determination theory in the Yangtze River Delta, the greater the gap in R & D input level, the more conducive to enhance the flow of knowledge production factors between cities and promote knowledge cooperation. Based on this, this paper puts forward the fifth research hypothesis:

H5: the gap in the level of scientific input has a positive effect on knowledge cooperation.

3. Empirical Analysis

3.1. Data Selection and Model Construction
UA-YRD in this paper mainly includes 26 cities: Shanghai, Nanjing, Wuxi, Changzhou, Suzhou, Yancheng, Nantong, Zhenjiang, Yangzhou, Taizhou, Hangzhou, Ningbo, Jiaxing, Shaoxing, Huzhou, Zhoushan, Jinhua, Taizhou, Hefei, Wuhu, Tongling, Maanshan, Anqing, Chizhou, Chuzhou and Xuancheng. Knowledge cooperation data are mainly from the SCI and SSCI databases of Web of Science, and the knowledge cooperation data of any two cities in 26 cities in the Yangtze River Delta are retrieved; the research method is mainly using social network analysis, through Ucinet and Netdraw software to verify the main influencing factors of the knowledge cooperation network of UA-YRD from 2009 to 2013 and from 2014 to 2018.

Based on above theoretical analysis, construct model of influencing factors of knowledge cooperation network in UA-YRD:

\[ Y_{ij} = f(Dis_{ij}, Gdp_{ij}, Ins_{ij}, Outp_{ij}, Inp_{ij}) \]  (2)

The dependent variable \( Y_{ij} \) is the change in the amount of knowledge cooperation, expressed as the difference between the amount of knowledge cooperation in cities i and j between 2014-2018 and 2009-2013, independent variables \( Dis_{ij} \) is geographic distance between city i and j, \( Gdp_{ij} \) is the gap between the economic development levels of cities i and j, expressed by the gap in GDP per capita, and \( Ins_{ij} \) is the institutional proximity of cities i and j, expressed by equation (1), \( Outp_{ij} \) is the gap in the level of scientific research output of cities i and j, expressed by the gap in the number of patent applications per capita, \( Inp_{ij} \) is the gap between the level of scientific research input in cities i and j, expressed by the gap in scientific research funding per capita. These data are derived from WOS.
database and Shanghai Statistical Yearbook, Jiangsu Statistical Yearbook, Zhejiang Statistical Yearbook and Anhui Statistical Yearbook.

3.2. QAP Regression Analysis

Use Ucinet software to perform QAP regression analysis on formula (2) after 5000 times of random replacement. The regression results are shown in Table 1.

| Variables   | Regression coefficients | Standardized regression coefficient |
|-------------|-------------------------|-----------------------------------|
| lnDis\(_{ij}\) | -1.066***               | -0.285***                         |
| lnGdp\(_{ij}\) | -0.279**                | -0.123**                          |
| lnS\(_{ij}\)  | 2.351***                | 0.544***                          |
| lnOutp\(_{ij}\)| -0.339***               | -0.149***                         |
| lnInp\(_{ij}\) | 0.423***                | 0.224***                          |
| R\(^2\)      |                         | 0.511                             |
| Adj-R\(^2\)  |                         | 0.508                             |
| P            |                         | 0.000                             |

Note: p value: ***p<0.01, **p<0.05, *p<0.1.

It can be seen from Table 1 that the geographical distance, the gap in the level of economic development, and the gap in the level of scientific research output have significant negative impacts on the knowledge cooperation network in UA-YRD and the correlation coefficients are -0.285, -0.123, -0.149, verifying Hypothesis 1, Hypothesis 2, and Hypothesis 4 respectively. Institutional proximity and gap in the level of scientific research input have positive impacts on the knowledge cooperation network in UA-YRD, and the correlation coefficient are 0.544 and 0.224, verifying Hypothesis 3 and Hypothesis 5 respectively. It can be seen that the knowledge cooperation network in UA-YRD is significantly affected by five factors: geographical distance, gap in the level of economic development, institutional proximity, gap in the level of scientific research output and gap in the level of scientific research input.

3.3. Robustness Test

The article draws on the method of determining the scientific output capacity gap in Klunderttvd et al. (1994) [9]. The calculation formula for the scientific output capacity gap is:

\[
\text{lnOutp}_{ij} = (\ln x_i - \ln x_j) \times (1 / x_j - 1 / x_i)
\]  

(3)

where \(x_i\) and \(x_j\) represent the knowledge output (i.e., literature output) of cities \(i\) and \(j\) respectively.

In order to ensure the reliability of the main conclusions of this article, a robustness test will be carried out: (1) the explanatory variable \(Y_{ij}\) will be replaced by the sum of the number of knowledge cooperation between the two phases of city \(i\) and \(j\) in 2014-2018 and 2009-2013, and model 2 will be constructed and carried out QAP regression analysis; (2) replace \(Y_{ij}\) with the amount of knowledge cooperation between the two cities \(i\) and \(j\) in 2014-2018, build Model 3 and perform QAP regression analysis; (3) unchanged \(Y_{ij}\), replace gap in the level of scientific research output with gap in the level of scientific research output capacity, Construct Model 4 and perform QAP regression analysis; (4) replace \(Y_{ij}\) with the amount of knowledge cooperation in cities \(i\) and \(j\) between 2014-2018 and 2009-2013, replace gap in the level of scientific research output with gap in the level of scientific research output capacity, and build a model 5 and perform QAP regression analysis; (5) replace \(Y_{ij}\) with the amount of knowledge cooperation between cities \(i\) and \(j\) in 2014-2018, replace the gap in the level of scientific research output with gap in the level of scientific research output capacity, build model 6 and perform QAP regression analysis. The results of QAP regression are shown in Table 2.
Table 2. Robustness test

|                | Model 1       | Model 2       | Model 3       | Model 4       | Model 5       | Model 6       |
|----------------|---------------|---------------|---------------|---------------|---------------|---------------|
| lnDis$_{ij}$   | -0.285***     | -0.278***     | -0.274***     | -0.315***     | -0.308***     | -0.274**      |
| lnGdp$_{ij}$   | -0.123**      | -0.124**      | -0.124**      | -0.141**      | -0.135**      | -0.124**      |
| lnS$_{ij}$     | 0.544***      | 0.557***      | 0.558***      | 0.591***      | 0.605***      | 0.558***      |
| lnOutp$_{ij}$  | -0.149***     | -0.133***     | -0.138***     | -0.141**      | -0.157**      | -0.150***     |
| lnInp$_{ij}$   | 0.224***      | 0.247***      | 0.239***      | 0.155**       | 0.183***      | 0.173***      |
| R2             | 0.511         | 0.529         | 0.524         | 0.513         | 0.539         | 0.531         |
| Adj-R2         | 0.508         | 0.526         | 0.521         | 0.510         | 0.536         | 0.528         |
| p 值           | 0.000         | 0.000         | 0.000         | 0.000         | 0.000         | 0.000         |

Note: p value: ***p<0.01, **p<0.05, *p<0.1.

It can be seen from Table 2 that the robustness test results are basically consistent with the previous conclusions. This further verifies that the knowledge cooperation network of UA-YRD is significantly affected by five factors: geographical distance, gap in the level of economic development, institutional proximity, gap in the level of scientific research output, and gap in the level of scientific research input, among which geographical distance, gap in the level of economic development and gap in the level of scientific research output have significant negative impacts on it, while institutional proximity and gap in the level of scientific research input have significant positive impacts on it.

4. Conclusion

The results of theoretical and empirical analysis show that from the perspective of innovation networks, knowledge cooperation in UA-YRD is mainly affected by geographical distance, gap in the level of economic development, institutional proximity, gap in the level of scientific research output, and gap in the level of scientific research input. The distance, gap in the level of economic development, and gap in the level of scientific research output have significant negative impacts on it, while institutional proximity and gap in the level of scientific research input have significant positive impacts on it.

To promote knowledge cooperation in UA-YRD, the government should take specific measures based on the difference in factor endowments and economic development levels of cities, such as improving the level of infrastructure construction in marginal cities, increasing input in scientific research, increasing the level of informatization and scientific research output, and boosting Peripheral cities to improve the level of knowledge cooperation and the level of knowledge cooperation within UA-YRD [10]. In addition, the development of knowledge cooperation in UA-YRD needs to break through the restrictions of administrative boundaries and establish long-term cooperation mechanisms. The government should, through various policy guidance, encourage cities in the Yangtze River Delta to break through the constraints of provincial cooperation, break the constraints of geographical distance, level of economic development, institutional differences, level of scientific research output and level of scientific research input, and establish the long-term cooperation mechanism within UA-YRD that are driven by the core cities to promote the development of peripheral cities, and rationally distribute innovative resources, improve the level of knowledge cooperation and maintain stable and good cooperative relations.

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