HiLL PUBLISHING

Journal of Humanities, Arts and Social Science, 2024, 8(9), 2147-2152
https://www.hillpublisher.com/journals/jhass/
ISSN Online: 2576-0548
ISSN Print: 2576-0556

Measurement of Urban Innovation Efficiency Levels and Influencing Factors in the Yangtze River Delta Urban Agglomeration

Binshu Wang*, Xiaowei Duan

School of Resources and Environment, Henan University of Economics and Law, Zhengzhou 450011, Henan, China.

How to cite this paper: Binshu Wang, Xiaowei Duan. (2024) Measurement of Urban Innovation Efficiency Levels and Influencing Factors in the Yangtze River Delta Urban Agglomeration. *Journal of Humanities, Arts and Social Science*, 8(9), 2147-2152.
DOI: 10.26855/jhass.2024.09.021

Received: August 16, 2024
Accepted: September 14, 2024
Published: October 12, 2024

***Corresponding author:** Binshu Wang, School of Resources and Environment, Henan University of Economics and Law, Zhengzhou 450011, Henan, China.

Abstract

As the intersection of the "Belt and Road" and the Yangtze River Economic Belt, the Yangtze River Delta (YRD) urban agglomeration holds a crucial position in the national development framework. This paper utilizes panel data on innovation inputs and outputs from 26 cities within the YRD urban agglomeration to assess the innovation efficiency of the region from 2011 to 2022. The analysis employs Data Envelopment Analysis (DEA) and examines the factors influencing factors of innovation efficiency by using the Spatial Durbin Model. The findings indicate that: (1) From 2011 to 2022, the overall innovation efficiency of the YRD urban agglomeration exhibited a trend of gradual increase with fluctuations; (2) During the same period, the innovation efficiency of YRD cities displayed a spatial pattern of decline radiating from central cities such as Suzhou and Wuxi, with Chuzhou and Jinhua serving as peripheral nodes; (3) Factors such as the level of economic development, local government support, industrial foundation, financial development, and labor quality significantly impact local innovation efficiency.

Keywords

Yangtze River Delta; Innovation Efficiency; DEA; Spatial Durbin Model

1. Introduction

From the Fifth Plenary Session of the 18th CPC Central Committee, which put forward the five development concepts led by "innovation", to the leading role of innovation in the development of new quality productive forces, it highlights the crucial role of innovation for the high-quality development of China's economy under the new normal (Wang Jian, 2024). However, China still faces a series of problems such as insufficient innovation resources and a low conversion rate of innovation achievements (Cui et al., 2024), so optimizing the allocation of innovation resources plays an important role in the development of new-quality productive forces and the enhancement of national innovation level. As the intersection of the "One Belt One Road" and the Yangtze River Economic Belt, the Yangtze River Delta (YRD) urban agglomeration occupies an important position in the national development pattern. Taking the YRD urban agglomeration as the object of research, exploring how to scientifically and reasonably allocate the regional innovation resources is of great significance to improve the utilization rate of the urban resources and enhance the national innovation efficiency.

Existing research on urban innovation efficiency mainly focuses on four aspects. The first is the definition of urban innovation efficiency, which is the ratio between multiple innovation outputs and innovation factor inputs (Chi, Yu, & Li, 2004); the second is the measurement of urban innovation efficiency, the researchers select R&D personnel/funding inputs, science and technology expenditures in public financial expenditures to represent innovation

factor inputs, and select the number of patents filed/authorized and output value of high-tech products to represent innovation result outputs, and the measurement methods mainly include stochastic frontier production function (SFA) (Sheng et al., 2020), data envelopment analysis (DEA) (Huang et al., 2021) and the three-stage DEA model (Qiu, Zheng, & Wu, 2022) that combines the two methods. In addition, there are also studies that use patent authorization and R&D investment to directly calculate urban innovation efficiency (Lu, Ni, & Wu, 2024); the third is the analysis of differences in innovation efficiency, existing research from the perspective of spatial-temporal differences, the research object mainly focuses on the differences between cities (Cui et al., 2024) and urban agglomerations (Ye, Li, & Wang, 2021); Fourth, the factors affecting the innovation efficiency of the city, including the level of Internet development (Jiang, Li, & Wen, 2021), the changes in the economic system (Zhang, Cao, & Wu, 2023) and so on.

At present, there are relatively few studies on the differences in urban innovation efficiency in the region from the perspective of geography. Based on this, this paper utilizes DEA to measure the innovation efficiency of each city in the YRD urban agglomeration based on the input perspective and uses a spatial econometric model to explore the factors affecting the innovation efficiency of cities.

2. Research Methodology, Indicator Selection, Data Sources and Processing

2.1 Research Methods

2.1.1 Data envelopment analysis method

DEA is an evaluation method used to evaluate whether the testing units with multiple inputs and outputs under the same type of conditions are technologically efficient or not, and the result is between 0-1. Based on this, this paper uses DEAP 2.1 software and selects the output-oriented BBC model to measure the innovation efficiency of 26 cities in the YRD urban agglomeration from 2011 to 2022.

2.1.2 Spatial econometric model

As a spatial econometric model, the spatial Durbin model (SDM) (Elhorst, 2015) contains the spatial effects of independent and dependent variables and can degenerate into a spatial error model and spatial lag model under certain conditions. After testing, the Spatial Durbin Model (SDM), which contains endogenous and exogenous interaction effects, is selected in this paper.

2.2 Indicator Selection

According to the research of Huang Huan and Qiu Yi (Huang et al., 2021) (Qiu, Zheng, & Wu, 2022), etc., the number of S&T expenditures, education expenditures, and the number of employees in the scientific research and technology service industry in the local general public financial budget are selected to indicate the input of innovation factors; The number of patent applications and authorizations are selected to indicate the output of innovation results. However, in actual scientific R&D activities, there is a lag between the outcome of S&T innovation and the input of innovation factors, so this paper calculates the innovation efficiency of the cities in the YRD urban agglomeration with a lag of 1 year in innovation output. Seven variables were selected: level of economic development (GDP per capita), local support (percentage of expenditure on science, technology, and education), industrial base (number of industrial enterprises above scale per 10,000 people), level of financial development (balance of loans from financial institutions at the end of the year), openness to the outside world (actual utilization of foreign investment), level of informationization development (Internet access broadband), and labor quality (number of students per 10,000 people in school) are selected with reference to the study of Sheng Yanwen (Sheng et al., 2020) and others.

2.3 Data Sources and Processing

The socio-economic statistics used in this paper mainly come from the 2012-2023 “China Urban Statistical Yearbook” as well as Jiangsu, Zhejiang, and other provincial and municipal statistical yearbooks, with a small portion of missing data made up by linear interpolation; Vector data such as maps comes from the standard map service system of the State Bureau of Surveying, Mapping and Geographic Information (http://bzdt.ch.mnr.gov.cn/index .html). In addition, to avoid the influence of data unit differences and heteroscedasticity on the regression results, the influencing factors are standardized.

3. Analysis of Results

3.1 Results of Innovation Efficiency Measurement

Overall, the innovation efficiency of the YRD urban agglomeration shows an overall trend of increasing fluctuation (Figure 1). It shows an upward trend in the time periods of 2011-2013 and 2017-2021 and a downward trend in 2013-2017. Among them, the average urban innovation efficiency in the YRD urban agglomeration was the lowest in 2011, at 0.658, and the average urban innovation efficiency was the highest in 2013, at 0.783. In May 2010, The State Council formally approved the implementation of the "Regional Plan for the Yangtze River Delta Region", which pointed out that it was necessary to strengthen the construction of innovation curbing capacity, and to enhance the ability of scientific and technological innovation and industrial integration and development. With policy support, the innovation infrastructure construction of the YRD urban agglomeration was gradually improved, especially in transportation and information, providing convenient conditions for the flow of innovation resources, thus promoting the innovation efficiency of the YRD urban agglomeration. After 2012, China's economy entered a new normal, and the industrial structure began to be gradually optimized and upgraded. From 2013 to 2017, the YRD urban agglomeration was in the pain period of economic structural adjustment, with greater pressure on the transformation and upgrading of traditional industries, and the development of emerging science and innovation industries had not yet formed a scale, thus resulting in a decrease in the efficiency of innovation in the cities of the YRD urban agglomeration during this period. However, with the adoption of the “YRD Urban Agglomeration Development Plan” by the State Council in 2016, regional synergistic development has been continuously strengthened, and a favorable situation of resource sharing and complementary advantages has been formed between the regions, which has improved the overall innovation efficiency of the region. From the perspective of each city (Figure 2), the highest average value of innovation efficiency in 2011-2021 is Jinhua, 0.925, and the lowest is Zhoushan, 0.251. The reason for the lowest innovation efficiency in Zhoushan may be due to the limitations of industrial conditions. Zhoushan's industrial structure is dominated by the secondary and tertiary industries, but the secondary industry is dominated by heavy industry and the aquatic products processing industry, which lacks investment in innovation resources.

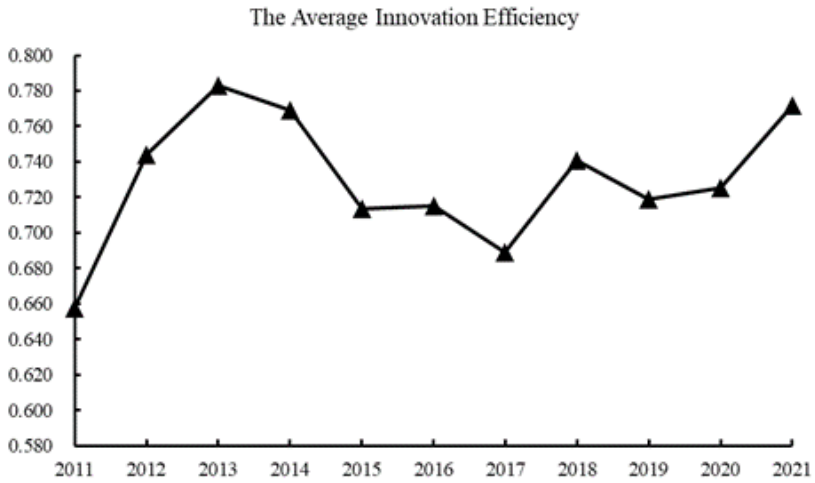

Figure 1. The average innovation efficiency in cities in the YRD.

To further understand the distribution of innovation efficiency (C) in YRD cities, the standard deviation method was used to categorize the innovation efficiency of YRD urban agglomeration into low innovation efficiency, relatively low innovation efficiency, moderate innovation efficiency, relatively high innovation efficiency, and high innovation efficiency. Three-time nodes, 2011, 2016, and 2021 (Figure 3), were selected to explore the spatial and temporal evolution characteristics of urban innovation efficiency in the Yangtze River Delta.

Overall, the innovation efficiency of cities in the YRD shows a spatial pattern with Suzhou and Wuxi as the center, Chuzhou and Jinhua as the nodes, and gradually decreasing to the surrounding cities. The center city led by Suzhou has gathered a large number of researchers, R&D funds, and other innovation factors, and possesses a relatively perfect innovation infrastructure. Its innovation development level is relatively high, and it relies on the “diffusion

effect" to drive the innovation development of the surrounding cities, forming a contiguous highland of innovation efficiency. Specifically, from 2011 to 2021, high-efficiency innovation cities in the YRD urban agglomeration showed a trend of changing from north to south and then northward, while relatively high-innovation efficiency cities showed a trend of spreading from north to south and from east to west. High and relatively high innovation efficiency cities rose from 10 in 2011 to 17 in 2021, of which, relatively high innovation efficiency cities in Anhui and Zhejiang provinces grew steadily, high and relatively high innovation efficiency cities in Jiangsu province gradually increased, and high innovation efficiency cities show a trend of decreasing first and then increasing. Moderate innovation efficiency cities change from the center of continuous distribution to the surrounding scattered distribution, accounting for 38.46%, 19.23%, and 19.23% of the YRD urban agglomeration cities in 2011, 2016, and 2021, respectively, and most of the moderate innovation efficiency cities are distributed in Anhui and Zhejiang provinces. Low and relatively low innovation cities, such as Anqing and Zhoushan, are mostly far away from the center city led by Suzhou and are distributed on the edge of the YRD urban agglomeration in a dotted manner. These cities are relatively lacking in the supply of innovation resources, lagging behind in the development of innovation industries, and limited in the input of innovation factors, which leads to a certain degree of disadvantage in the level of urban innovation efficiency.

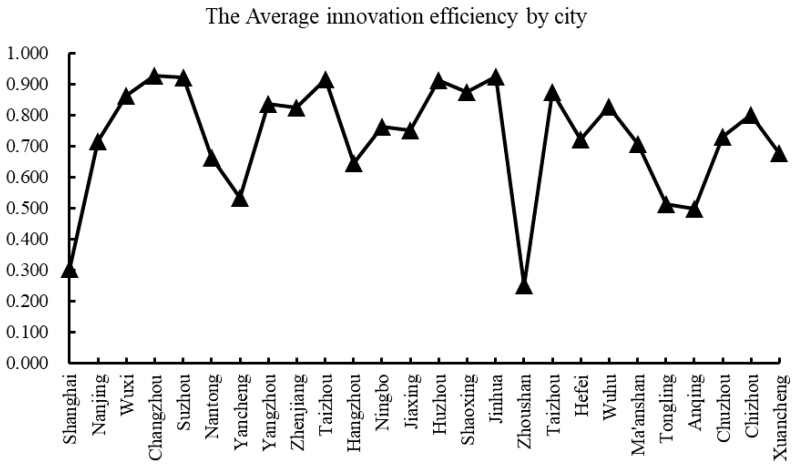

Figure 2. The average innovation efficiency by city.

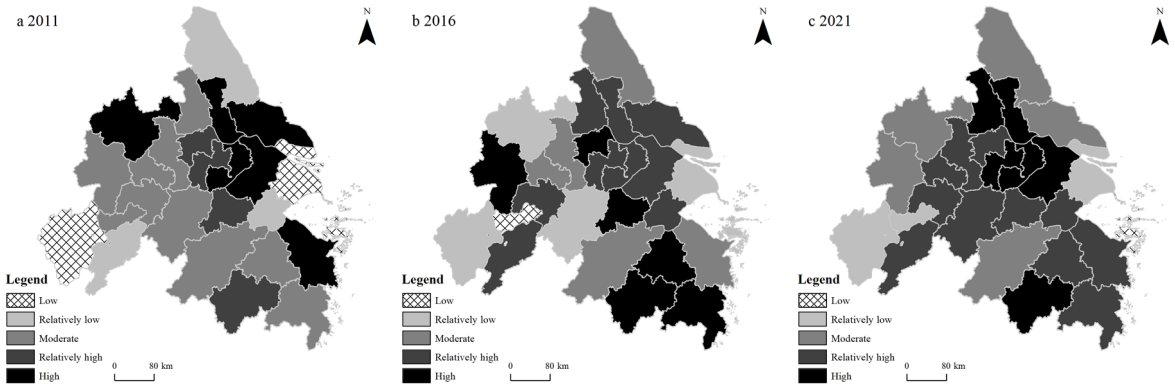

Figure 3. Spatiotemporal distribution of innovation efficiency in cities in the YRD.

3.2 Factors Affecting Innovation Efficiency

3.2.1 Spatial autocorrelation analysis

The global Moran'I index was utilized to examine the spatial clustering form of the innovation efficiency of YRD cities. As a result, the spatial econometric model is used to explore the influencing factors of urban innovation efficiency in the YRD.

3.2.2 Spatial econometric analysis

The results of the spatial Durbin model are shown in Table 1, in terms of direct effect, the level of economic development has a significant positive impact on local innovation efficiency, indicating that the improvement of the level of economic development can provide sufficient financial guarantee for local innovation activities, forming a virtuous circle of economic growth and innovation efficiency; Industrial base also passed the test of significance at the level of 5%, indicating that the industrial base has a significant impact on the improvement of local innovation efficiency. The strong industrial base means that relevant industries can form scale effect and agglomeration effect locally, which is conducive to the sharing of innovation resources and reduction of innovation cost within the industrial cluster; The level of financial development has a significant positive effect on the enhancement of local innovation efficiency, and the enhancement of the level of financial development, on the one hand, can provide financial guarantee for enterprises, research institutions and other innovation subjects, and on the other hand, can optimize the allocation of resources and promote the development of innovation efficiency. The marginal effect of labor quality is the largest, which means that talent is still an important factor affecting innovation efficiency; The negative effect of local support on innovation efficiency means that local support hinders the improvement of local innovation efficiency. Due to the competition among local governments, they blindly increase fiscal expenditures in the field of innovation, which has a "crowding out effect" on the high-efficiency funds, thus hindering the improvement of innovation efficiency. In terms of indirect effects, only the level of financial development and the level of openness to the outside world pass the significance test.

Table 1. Estimation results of spatial Durbin model

	Geographic adjacency matrix					
		t-statistic	**direct effect**	**t-statistic**	**indirect effect**	**t-statistic**
Economic development level	0.24*	-1.77	0.24*	-1.72	-0.26	-1.30
Local support	-0.41***	(-4.29)	-0.42***	-4.60	-0.09	-0.49
Industrial base	0.43**	-2.17	0.44**	2.44	-0.15	-0.40
Financial development level	0.56*	-1.89	0.51*	1.76	-1.24***	-2.63
Open to the outside world	-0.16	(-0.57)	-0.10	-0.38	1.47***	2.62
Informatization development level	0.05	-0.22	0.06	0.27	0.01	0.02
Quality of labor force	0.58**	-2.32	0.61**	2.34	0.63	0.94
W·Economic development level	-0.26	(-1.43)				
W·Local support	0.00	-0.02				
W·Industrial base	-0.22	(-0.67)				
W·Financial development level	-1.13***	(-2.70)				
W·Open to the outside world	1.19***	-2.75				
W·Informatization development level	0.01	-0.03				
W·Quality of labor force	0.35	-0.69				
rho	0.23***	-3.06				
sigma2_e	0.02***	-11.90				
Observations	286	286				

Notes: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively.

4. Conclusions

This paper takes 26 cities in the YRD urban agglomeration from 2011-2022 as the research object, calculates the innovation efficiency of each city through the DEA model, and constructs the spatial Durbin model to explore the influencing factors of urban innovation efficiency. The main conclusions are as follows:

(1) The overall innovation efficiency of the YRD urban agglomeration in 2011-2022 shows an increase in fluctuation, of which, it shows an upward trend in the two time periods of 2011-2013 and 2017-2021 and a downward trend in 2013-2017.

(2) The innovation efficiency of cities in the YRD from 2011 to 2022 shows a spatial pattern centered on Suzhou, Wuxi, etc., with Chuzhou and Jinhua as the nodes, and gradually decreasing to the surrounding cities. High-efficient innovation cities show a trend of changing from north to south and then north; Relatively high innovation efficiency cities show a trend of spreading from north to south and from east to west; Moderate efficiency innovation cities change from a continuous distribution in the center to a scattered distribution around them; Low and relatively low-efficiency innovation cities are dotted around the edge of the YRD urban agglomeration.

(3) There is a significant spatial spillover effect of innovation efficiency in the YRD urban agglomeration. The level of economic development, local support, industrial base, financial development level, and labor quality have significant effects on local innovation efficiency.

References

Chi Renyong, Yu Xiao-Fen, & Li Zheng-Wei. (2004). Analysis of the differences in technological innovation efficiency between eastern and western regions of China and their causes. *China Soft Science*, *08*, 128-131+127.

Cui Dan, Lv Shuang, Huang Yino, & Li Guoping. (2024). Analysis of regional differences and industrial characteristics of innovation efficiency in Chinese cities. *Science and Technology Management Research*, *03*, 85-98.

Elhorst, J. P. (2015). Matlab software for spatial panels. *International Regional Science Review*, *3*, 389-405.

Huang Huan, Li Jiawei, Xiao Yi, Wang Jue, & Wang Xiaochen. (2021). Innovation efficiency and influencing factors of cities in the Loess Plateau. *Journal of Central China Normal University (Natural Science Edition)*, *05*, 798-807.

Jiang Renai, Li Dongmei, & Wen Jun. (2021). Research on the impact of Internet development level on urban innovation efficiency. *Contemporary Economic Science*, *04*, 77-89.

Lu Yanjin, Ni Qingshan, & Wu Di. (2024). Evolution and influencing factors of innovation efficiency in China's 14 major city clusters. *Economic Geography*, *01*, 57-65.

Qiu Yi, Zheng Ze, & Wu Jianjun. (2022). Spatiotemporal changes and spillover effects of innovation efficiency in the Yangtze River Midstream Urban Agglomeration. *Yangtze River Basin Resources and Environment*, *12*, 2582-2596.

Sheng Yanwen, Luo Huasong, Song Jinping, Zhao Jinli, & Zhang Xuebo. (2020). Innovation efficiency, influencing factors and spatial spillover effects of five major city clusters along the eastern coast of China. *Geography Research*, *02*, 257-271.

Wang Jian. (2024). Impact of the implementation of the “One Belt One Road” initiative on urban innovation efficiency and its spatial spillover. *Science and Technology Management Research*, *07*, 70-79.

Ye Tanglin, Li Lu, & Wang Xueying. (2021). Comparative study on innovation efficiency and influencing factors of three major city clusters in eastern China. *Science and Technology Progress and Countermeasures*, *11*, 36-45.

Zhang Hongxia, Cao Fengtong, & Wu Aimin. (2023). Pilot free trade zone construction, economic system change and urban innovation efficiency. *Industrial Technology and Economics*, *09*, 151-160.