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Spatial Correlation Characteristics and Inner Mechanism of Urbanization Dataset of the Yangtze River Delta

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Abstract: The Yangtze River Delta includes 41 prefecture-level cities in Shanghai, Jiangsu, Zhejiang, and Anhui provinces. On the basis of economic, population, and built-up area data from the study area, and using China's Statistical Yearbooks, we examined the scale and strength of development of spatial correlation based on urbanization development (UD) and urbanization spatial correlation intensity (UCI). Using Moran's I index, LISA (local indicators of spatial association) agglomeration, and the Tsui–Wang (TW) index, we analyzed the differences in spatial development and spatial relationships in the Yangtze River Delta. Urbanization speed (US) reflects the overall development of a city. Results showed that clear patterns coexist in the process of urbanization between the scale and hierarchy of regional urbanization and the level of spatial polarization and diffusion. The dataset included UCI data, Moran's I index data, and Tsui–Wang index data relating to the Yangtze River Delta, the economic, population, and built-up area growth rate data of core cities in the Yangtze River Delta, and the US and UD data of the main cities in the Yangtze River Delta during the study period (1995–2015). The dataset is archived in .xlsx format with data size of 64 KB.

Keywords: spatial correlation; spatial polarization; spatial diffusion; spatio-temporal evolution

Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2020.09.09.V1.

1 Introduction

China has undergone rapid urbanization in recent years and the regional differentiation of China's urbanization process has received considerable attention[1]. Studying developmental planning regarding regional cities and urban agglomerations is of great importance for re-

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[2] Li, M. D., Cui, Y. P., Liu, X., *et al*. Spatial correlation characteristics and inner-mechanism of urbanization dataset in the Yangtze River Delta (1995–2015) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2020. https://doi.org/10.3974/geodb.2020.09.09.V1.

vealing the spatial correlation of regional urbanization development and the evolution law of the spatial diffusion of urbanization.

Spatial polarization in the process of urbanization is widespread in developing and developed countries. The phenomenon of spatial polarization and diffusion has attracted interest globally. Research suggests that levels of urbanization show significant spatial dependence[2–3]. Previous studies have examined the impact of urban networks from the perspectives of multiple scales (e.g., regional cities, urban agglomerations, monolithic cities, and inner-city space) to multiple fields (e.g., population, capital, transportation, and science and technology flows). Most of this research involved analysis of the spatial correlation of urbanization from the perspectives of urban networks, central cities, and spheres of influence. However, such an approach cannot measure the spatial correlation and interaction among cities[4–5]. Although network research can indicate the mobility of various urbanization elements through vectors of points and lines, it is difficult to use this technique to express the level of urbanization of a region. Few studies have systematically analyzed and measured the spatial correlation characteristics of regional cities by combining spatial polarization and diffusion through integration of multiple indicators under the dual dimensions of time and space[5–8]. This study used economic, population, and built-up area data together with consideration of spatial polarization and diffusion to systematically analyze the characteristics of the spatial correlation and inner mechanism among regional cities. On the basis of this analysis, we constructed a dataset that revealed the spatial correlation characteristics and inner mechanism of the Yangtze River Delta. The dataset is one of basic information for practical guidance for regional studies.

2 Metadata of the Dataset

The metadata of the "Spatial correlation characteristics and inner mechanism of urbanization in the Yangtze River Delta (1995–2015)" [9] is summarized in Table 1. It includes the name, authors, geographical region, year of the data, temporal resolution, spatial resolution, data files, data publisher, and data sharing policy, etc.

3 Methods

3.1 Data Sources

In this study, data of city-level GDP, registered household population, and the urban built-up area of the Yangtze River Delta were used as indicators with which to measure regional economic urbanization, population urbanization, and spatial urbanization, respectively. Four periods were considered during 1995–2015, each covering a 5-year interval. The data were obtained from the Shanghai, Zhejiang, Anhui, and China City Statistical Yearbooks[11].

We used the metrics of overall urbanization development (UD) and urbanization spatial correlation intensity (UCI) to reflect the relative overall power of a city within the study area, changes in development within the region, and strength of the spatial linkages in urban development. Urban economy, urban population, and urban space were linked to determine the scale and spatial distance correlation of cities based on the first law of geography and relevant literature[5,8]:

$$d_i = \sqrt[3]{p_i \times l_i \times e_i} \tag{1}$$

$$R_{ij} = \varphi_1 r_{zx} + \varphi_2 r_{gl} + \varphi_3 r_{gt} \tag{2}$$

Table 1 Metadata summary of the "Spatial correlation characteristics and inner-mechanism of urbanization dataset in the Yangtze River Delta (1995–2015)"

Items	Description
Dataset full name	Spatial correlation characteristics and inner-mechanism of urbanization dataset in the Yangtze River Delta (1995–2015)
Dataset short name	SpatialCorrelationUrbanYRD_1995-2015
Authors	Li, M. D. ABG-3925-2020, College of Environment and Planning, Henan University, lmd@henu.edu.cn Cui, Y. P. ABG-4844-2020, College of Environment and Planning, Henan University, cuiyp@lreis.ac.cn Liu, X. ABG-5980-2020, College of Environment and Planning, Henan University, 1610131043@vip.henu.edu.cn Li, D.Y. ABG-4865-2020, College of Environment and Planning, Henan University, 104753190125@vip.henu.edu.cn Fan, L. ABG-4963-2020, College of Environment and Planning, Henan University, 1529290254@qq.com Zhao, W. ABG-6029-2020, College of Environment and Planning, Henan University, 10130056@vip.henu.edu.cn
Geographical region	The area of Yangtze Region Delta is 35×10^4 km^2, including, Shanghai, and Zhejiang, Jiangsu, Anhui provinces
Year	1995–2015 Data format .xlsx Data size 64 KB
Data files	The urbanization spatial correlation intensity (UCI) data, the Moran's I and Tsui-Wang index data, the economic, population, built-up area growth rate data of core cities, the urbanization speed (US) data, the urbanization comprehensive development (UD) data of main cities in the Yangtze River Delta during 1995–2015
Foundations	National Natural Science Foundation of China (42071415, 41671425); Henan Natural Science Foundation (202300410049)
Computing environment	ArcGIS10.5
Data publisher	Global Change Research Data Publishing & Repository http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing &Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[10]
Communication and searchable system	DOI, DCI, CSCD, WDS/ISC, GEOSS, China GEOSS, Crossref

$$UD_i = \frac{d_i}{\sum_{i=1}^{n} d_i} \tag{3}$$

$$UCI_{ij} = \frac{d_i \times d_j}{R_{ij}^2} \tag{4}$$

where p_i, l_i, and e_i represent the registered household population, built-up area, and GDP of city i, respectively; φ_1, φ_2, and φ_3 are weighted indices; r_{zx}, r_{gl}, and r_{gt} represent the straight-line distance, highway distance, and high-speed rail distance, respectively; and R_{ij} is the integrated distance between city i and city j. The larger the value of UD_i, the stronger the integrated urbanization of the city is. A larger UCI_{ij} indicates stronger spatial distance correlation between city i and city j.

Local autocorrelation analysis is complementary to the Tsui–Wang (TW) index and both

were used to measure the spatial urbanization differences in the study area. Moran's *I* index and the local indicators of spatial association (LISA) agglomeration are commonly used indicators of spatial autocorrelation. Although the polarization index quantified the degree of polarization of regional development, it could not indicate the specific regions of polarization in space. On the basis of LISA agglomeration maps, we observed the diffusion effects and polarization characteristics of the region[6,12–13]. Factors such as population, built-up area, and urban industry all have substantial impact on the process of urbanization. The urbanization speed (US) was determined based on differences in the relative development rates among the various cities. The US reflects the overall development of a city:

$$US=\alpha_1 P_i+\alpha_2 L_i+\alpha_3 E_i\,, \tag{5}$$

where α_1, α_2, and α_3 are index weightings; P_i is the speed of population development; L_i is the speed of urban land use change; and E_i is the speed of urban economic development.

3.2 Technical Route

We constructed a methodological framework for this research according to the first law of geography and relevant references. The dataset was based on population, economic, built-up area, and distance data obtained from corresponding statistical yearbooks. The technical route adopted in this research is illustrated in Figure 1.

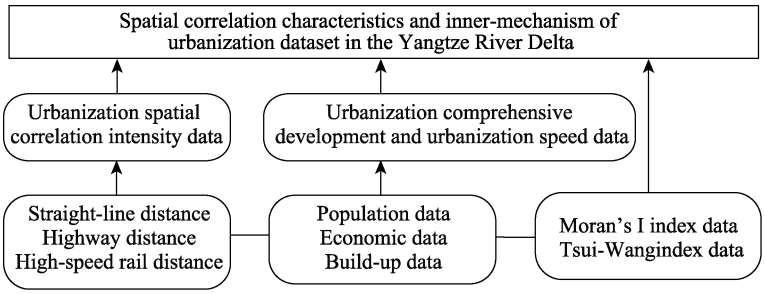

Figure 1 Flowchart of the dataset development

4 Data Results

4.1 Data Products

The dataset included UCI, Moran's I index, and TW index data relating to the Yangtze River Delta region, the economic, population, and built-up area growth rate data of the core regional cities, and the urbanization speed and urbanization development data of the main cities in the Yangtze River Delta during 1995–2015. We used the UCI to reflect the strength of the spatial linkages in the regional urban development. The economic, population, and built-up area growth rate data, and the US and UD data based on the urban economy, urban population, and urban space, were linked to determine the scale and spatial distance correlation of the cities based on the first law of geography and relevant literature.

4.2 Data Results

The UD and UCI reflect the relative overall importance of cities and the variation within the region in space and time. Overall, the pattern of importance within the Yangtze River Delta region did not change obviously. During the study period, the hierarchical structure of urban development showed five tiers in terms of spatial distribution (Figure 2). Shanghai was in the first tier, and Nanjing and Hangzhou were added to the second tier in 2005. The distance

correlation strength of urbanization in the Yangtze River Delta also showed obvious spatial distribution characteristics (Figure 3), and the areas with high UCI levels were centered in the east. Shanghai, Suzhou, Nanjing, and Hangzhou were strong links in the development of urbanization, and urbanization development in the study area showed obvious spatial agglomeration.

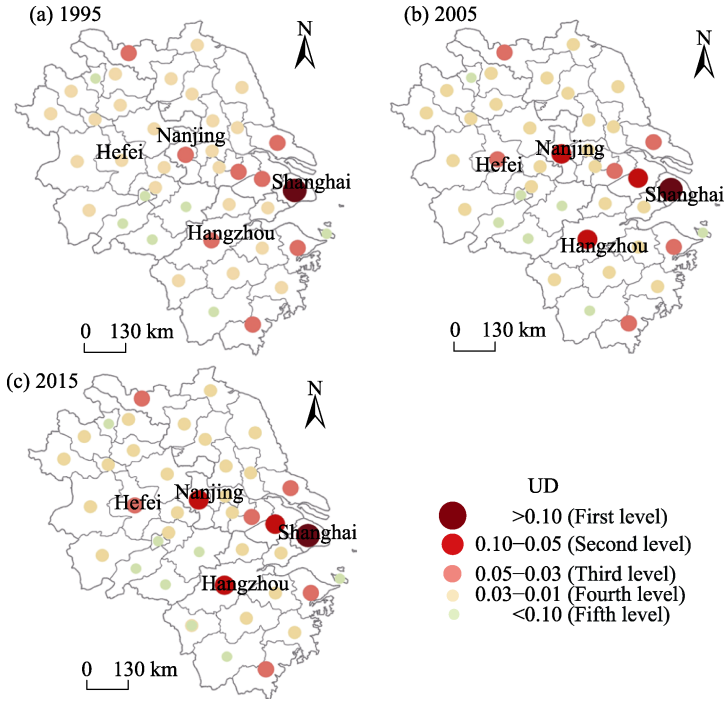

Figure 2 City-level structural maps of the Yangtze River Delta

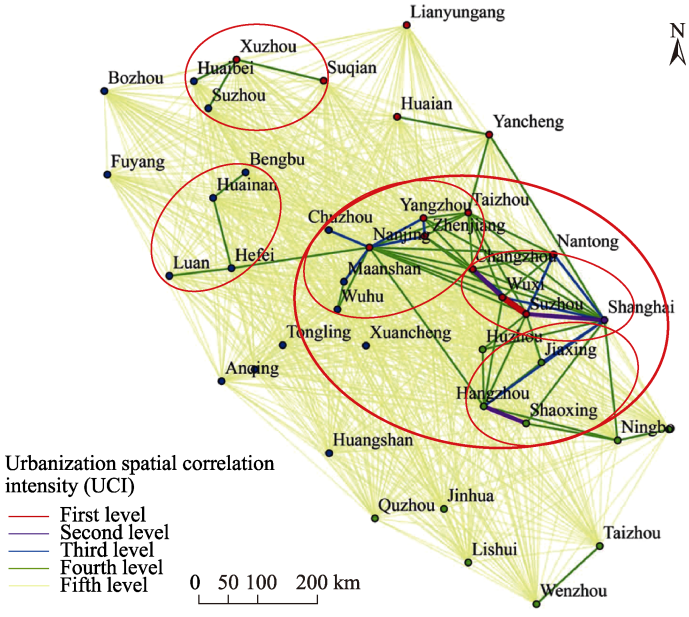

Figure 3 Spatial urban correlation intensity (UCI) map of urbanization in the Yangtze River Delta

Comparison of the TW index and Moran's I index in the Yangtze River Delta revealed that the TW index first increased and then decreased (Figure 4). However, the Moran's I index decreased in 2000 and then increased in 2005. Spatial polarization in the Yangtze River Delta intensified at the initial stage of our study, but then weakened as spatial development subsequently became more balanced.

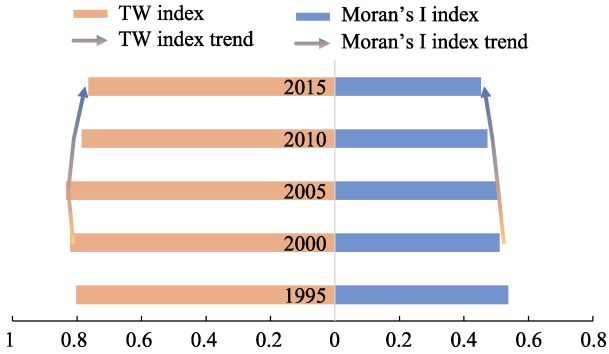

Figure 4 The Tsui–Wang index (TW) and Moran's I index in the Yangtze River Delta (1995–2015)

The data on urbanization in the Yangtze River Delta region showed the characteristics of spatial diffusion. Spatially, the high-value area shifted from the coast to the interior, and it showed a changing trend from east to west and south to north (Figure 5). It is clear that Shanghai's pattern of diffusion spread in the built-up area after 2000. Hangzhou, Nanjing, and Suzhou were all the focus of increasing polarization, which then weakened in the subsequent urbanization process

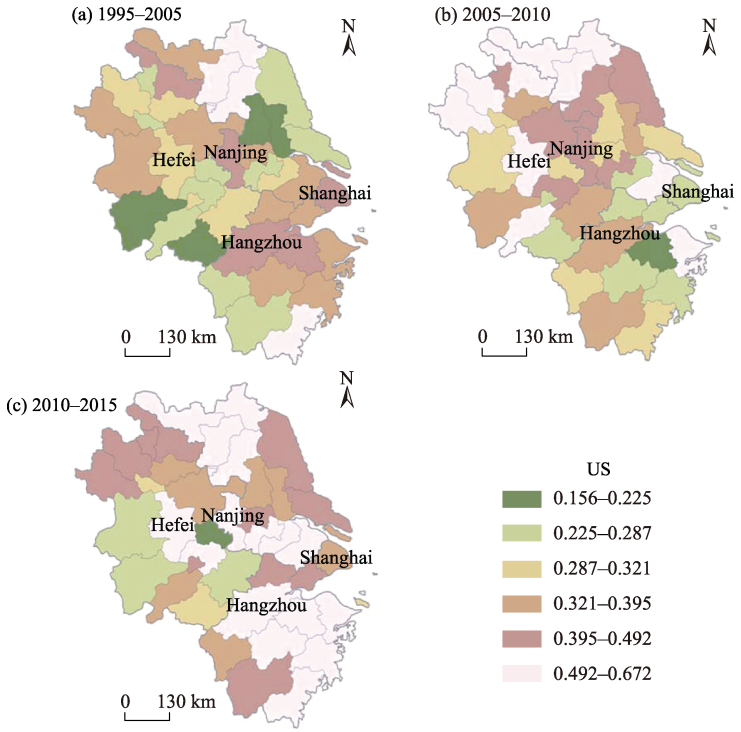

Figure 5 Map of urbanization speed value of the Yangtze River Delta (1995–2015)

Shanghai, Nanjing, Hangzhou, Suzhou, and Hefei are the five core cities in the Yangtze River Delta. There were significant differences in their level of urbanization during the study period but these differences declined over time. In the overall process of urbanization, economic urbanization was preemptive, built-up area urbanization was generally consistent with economic growth, and population urbanization had a certain lag. Furthermore, the urbanization process was spatially diffuse and recursive. Spatially, cities with higher levels of urbanization drove the development of neighboring cities (Figure 6).

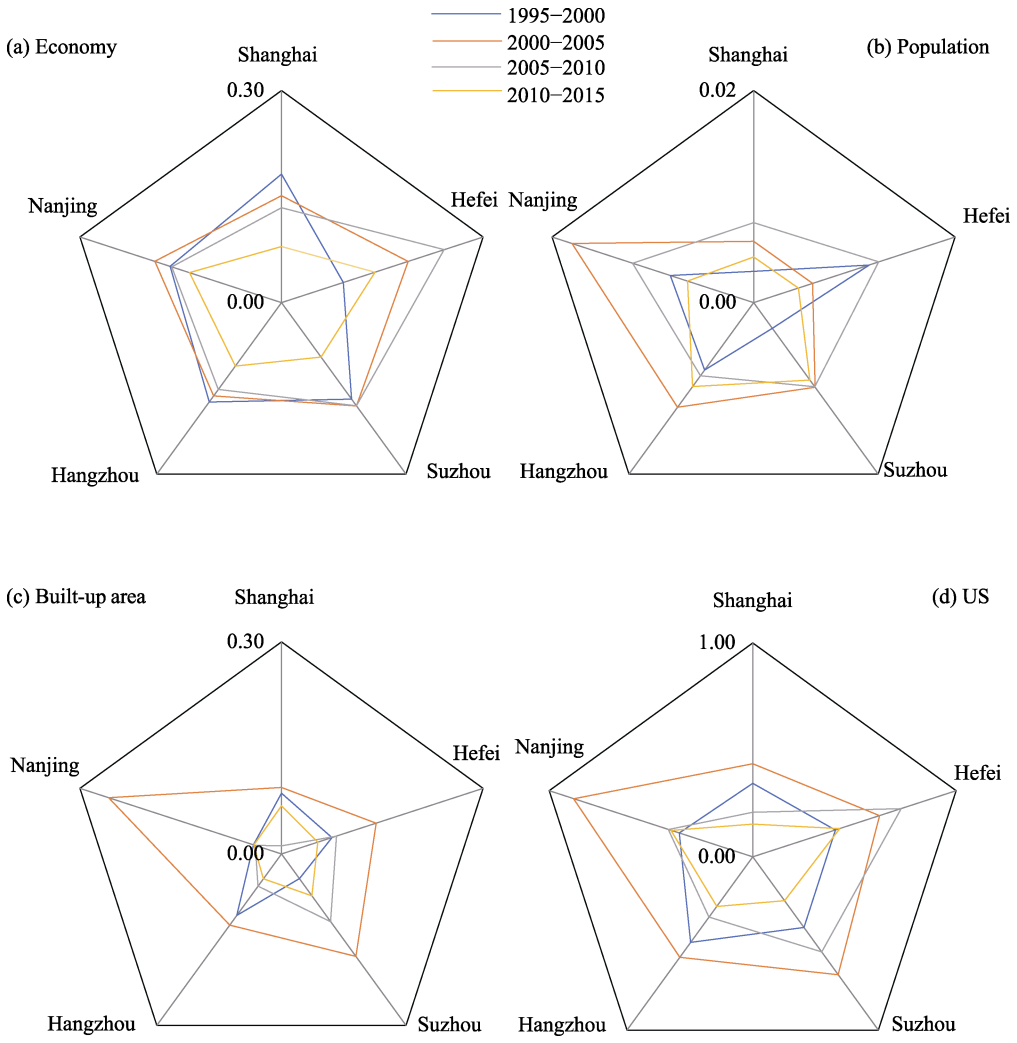

Figure 6 Radar map of economic, population, built-up area growth rate, and urbanization speed (US) values of the five major cities in the Yangtze River Delta

The industrial level and differences of the cities in the Yangtze River Delta expanded rapidly and industrial upgrading within the region was significant during the study period. Regional industrial upgrading promotes expansion of the level and differentiation of industries, which further promotes the process of industrial transfer spatially. The spatial change of the regional industrial structure reflects the industrial transfer, revealing the characteris-

tics of urbanization and the reasons for its evolution. Industrial flow deeply reflected the process of regional economic development and has strong connection with the phased regional development (Figure 7).

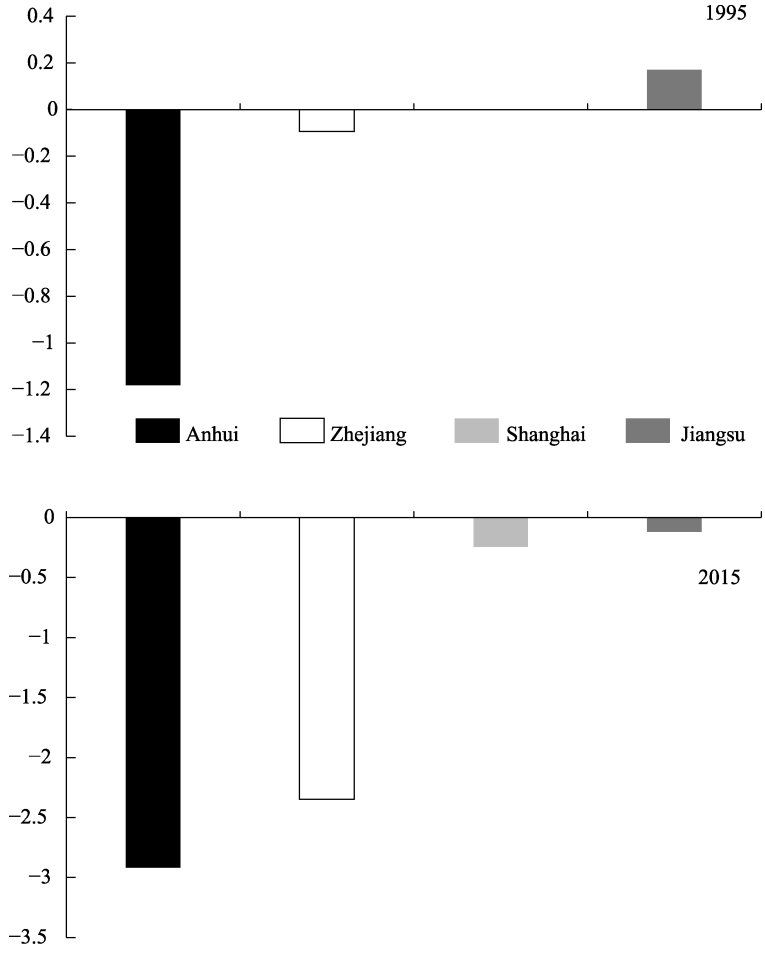

Figure 7 Industrial composition differences between 1995 and 2015 in the Yangtze River Delta

5 Conclusion

We integrated economic, population, and urban built-up area data to examine the spatial correlation characteristics of urbanization and its evolution in the Yangtze River Delta region. The resultant dataset constructed following research comprised UCI, Moran's I index, and TW index data, the economic, population, built-up area growth rate data of the core cities in the Yangtze River Delta, and urbanization speed and urbanization development data of the main cities in the Yangtze River Delta. The results revealed that the Yangtze River Delta had a clear distribution of city tiers during 1995–2015, with Shanghai in the first tier, Nanjing, Hangzhou, and Suzhou in the second tier, and the remaining cities in the third, fourth, and fifth tiers. Moreover, the strongest spatial correlation was concentrated in eastern parts of the

Yangtze River Delta, and 10 cities including Shanghai, Suzhou, Wuxi, and Hangzhou constituted the densest part of the spatial connection of the urbanization network. The spatial evolution of urbanization in the Yangtze River Delta was characterized by the coexistence of cycles of polarization and diffusion. Analysis of the driving mechanisms revealed that the spatial characteristics of urbanization and its evolution in the Yangtze River Delta were influenced by regional industrial modernization and relocation. Industrial modernization shaped the spatial hierarchy and differentiation of industries and underpinned the spatial diffusion dynamics of industries within the region.

Author Contributions

Li, M. D., and Cui, Y. P. designed the algorithms of dataset. Li, M. D., Liu, X., and Li, D. Y. contributed to the data processing and analysis. Fan, L., and Zhao, W. contributed to the data validation. Li, M. D. wrote the data paper.

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