

Spatiotemporal Differentiation Pattern and Influence Mechanism of Urban Resilience in Jiangsu Province

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Abstract. This study from the "ecological environment-infrastructure-social livelihood-economic development" four aspects of urban toughness evaluation framework and index system, in 2012-2020 as the research object, based on GIS analysis platform, using entropy method, spatial autocorrelation, linear fitting and other spatial analysis method, Jiangsu urban toughness temporal differentiation evolution pattern, and reveal the influence mechanism through geographical detector. The study found that: (1) from the perspective of the spatial differentiation pattern, high in the south and low in the north, cold in the north, southern Jiangsu is the core area of high toughness hot spots, showing point distribution; northern Jiangsu is low toughness cold point area, showing surface distribution. (2) The spatial and temporal differentiation pattern of urban resilience in Jiangsu Province is formed by the interactive influence of ecological environment, infrastructure, social and people's livelihood, economic development and other factors, among which economic development is the dominant factor.

Keywords: Urban resilience; Spatial and temporal differentiation; Influence mechanism; Jiangsu Province.

1. Introduction

In 2012-2020, the cities in Jiangsu province statistical yearbook as a data source to build urban toughness evaluation index system, with the help of entropy method, ArcGis average center, space autocorrelation, geographical detector, analysis of urban spatial and temporal analysis pattern and its influence mechanism, to realize the high quality development of cities in Jiangsu province is of great practical significance.

2. Research design

Urban resilience evaluation involves economic, social, ecological, infrastructure and other four dimensions and comprehensive development, reference related literature and research results ^[1-4], guided by urban resilience theory and combined with the development situation of Jiangsu province, considering index systematic and integrity, based on the ecological environment, economic development, social livelihood, infrastructure level build four level indicators and 30 secondary indicators (table 1).

Ecological environment indicators include: green space rate of urban built-up area, urban per capita park green space area, industrial wastewater discharge, industrial utilization rate of solid waste, centralized treatment rate of sewage treatment plant, industrial dust discharge, industrial sulfur dioxide discharge, and harmless treatment rate of household waste.

Economic development indicators include: the tertiary industry, the balance of savings deposits of urban and rural residents, per capita GDP, public finance budget income, actual foreign direct investment, public finance budget expenditure, science and technology expenditure, and education expenditure.

Social and livelihood indicators include: urban actual road length, built-up area, number of Internet users, length of drainage pipes, and gas penetration rate.

Infrastructure indicators include: urban per capita housing area, urban civil car ownership, the number of hospitals, the number of ordinary institutions of higher learning, the number of urban

workers insured, the number of beds in urban health institutions, the ratio of teachers to students in ordinary schools, the number of basic medical insurance insured, and the number of urban population.

3. Results analysis

3.1 Space-temporal differentiation pattern of urban resilience in Jiangsu Province

3.1.1 Overall change characteristics

The 20 urban toughness index of Jiangsu Province from 2012 to 2020 was calculated by entropy method and made descriptive statistics. The results are shown in Table 1: The average ① overall urban resilience in Jiangsu Province showed an upward trend, from 0.279 in 2012 to 0.423 in 2020. The standard deviation of ② urban toughness value is between 0.092 and 0.137, and the surface dispersion degree is small and different between cities.③'s coefficient of variation decreased from 2012 to 2014, indicating that the coefficient of spatial difference was narrowed, the coefficient of variation gradually increased from 2014 to 2020, and the spatial difference of toughness between surface cities was expanded. The ④ skewness coefficient gradually increased and was both were positive, indicating that the number of areas with high value of urban resilience is increasing year by year between 2012 and 2020. The peak state coefficient of ⑤ showed an increasing trend, and the distribution of similar urban toughness values in Jiangsu province was concentrated.

Table 1. Descriptive statistics of urban toughness values in Jiangsu Province(self-painted)

year	average value	standard error	coefficient of variation	coefficient of skew	coefficient of kurtosis
2012	0.279	0.092	32.928%	1.110	0.954
2014	0.314	0.092	29.296%	1.432	1.432
2016	0.353	0.105	29.771%	1.450	1.533
2018	0.390	0.118	30.282%	1.574	1.803
2020	0.423	0.137	32.330%	1.546	1.572

3.1.2 Spatiotemporal differentiation features

ArcGis visualized urban toughness values in 2012-2020 (Figure 1), divided by Jenks optimal natural fracture method into low toughness ($R < 0.3$), lower toughness ($0.3 \leq R < 0.4$), moderate toughness ($0.4 \leq R < 0.5$), higher toughness ($0.5 \leq R < 0.6$), and high toughness ($R \geq 0.6$) (Figure 1). The results show that ① generally forms a spatial pattern of high toughness and high toughness dot distribution, moderate and low toughness surface distribution in Jiangsu province, and the overall urban toughness gradually changes from low toughness to moderate toughness with the time change. In ② 2012, the moderate urban resilience was Nanjing and Suzhou, the low urban resilience was Wuxi, and the other cities were all low toughness.③ In 2014, Suzhou city gradually turned to high toughness, Nanjing city maintained medium toughness unchanged, Nantong city turned to low toughness, the other cities are low toughness, the overall difference between the north and the south. ④ In 2016, Nanjing city and Suzhou city became high toughness, Xuzhou city, Yancheng city, Nantong city and Yangzhou city changed from low toughness to low toughness, and Wuxi city turned to moderate toughness, and the overall toughness value was gradually improved.⑤ In 2018, the overall urban resilience of Jiangsu province has been improved greatly, and many cities have realized the transformation from low toughness to low resilience. In ⑥ 2020, the spatial differentiation pattern of urban toughness in Jiangsu Province has been high in the south and low in the north. The Nanjing and Suzhou in the south are highly resilient, the southern Wuxi, Nantong and Xuzhou in the north are moderate toughness, and the central cities are relatively low toughness.

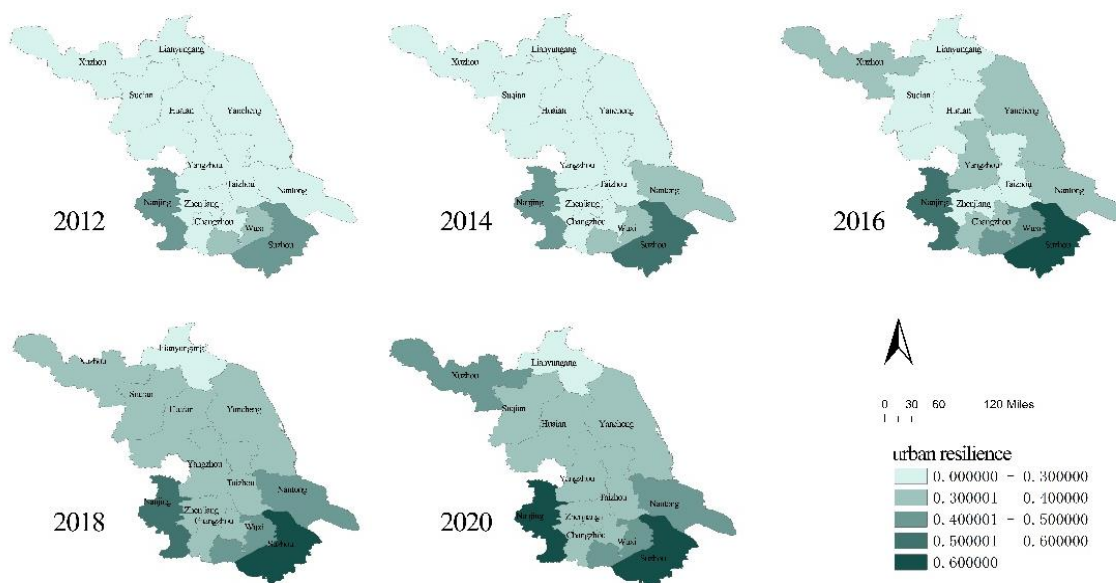


Figure 1. The spatial differentiation pattern of urban toughness in Jiangsu Province from 2012 to 2020(self-painted)

3.2 Spatial correlation analysis of urban resilience

3.2.1 Global auto-correlation

Based on the above analysis, in order to further explore the law of the spatial differentiation of urban toughness in Jiangsu Province, ArcGis was used to calculate the Moran of urban resilience in Jiangsu Province, sI index number. From Table 2, Moran, 2012-2016, The sI index was all positive and fluctuated greatly, indicating that the urban resilience space presents a spatial aggregation pattern during this period. From 2018 to 2020, the overall Z score was less than 1.96, which failed the significance test. Therefore, the spatial correlation of urban resilience in Jiangsu Province in 2018 and 2020 was weak, and the overall occurrence was more random. From the perspective of global autocorrelation, Jiangsu Province overall Moran, the sI index changes greatly, and the spatial aggregation is unstable during different periods.

Table 2. MoransI index number(self-painted)

year	I index number	Z score
2012	0.317	1.983
2014	0.343	2.154
2016	0.282	1.851
2018	0.105	1.061
2020	0.164	1.258

3.2.2 Local autocorrelation

Local Getis-OrdG* index analysis was performed by ArcGis and divided into five types: hotspot, sub-hotspot, mild, sub-cold and cold point with the help of natural breakpoint distribution (Figure 2). In general, the urban resilience of Jiangsu province presents the spatial characteristics of "hot south and cold north", and the spatial characteristics are relatively stable from 2012 to 2020. From the perspective of high value agglomeration and low value agglomeration, the following characteristics are presented:

Low urban resilience value is mainly concentrated in Xuzhou city, Lianyungang city, Yangcheng city, Taizhou city, Huai'an city and Suqian city in northern Jiangsu Province. As time goes by, Xuzhou city gradually turns into a mild area, and Lianyungang city and Huai'an city turn into secondary cold point areas. Urban resilience high high clustering is mainly concentrated in the southern Nanjing, Zhenjiang, Wuxi, Changzhou, Nantong and Suzhou.

This is mainly due to the impact of regional development differences in Jiangsu Province. According to statistics, from 2012 to 2020, the proportion of GDP in central Jiangsu province in the GDP of Jiangsu Province increased from 18.3% to 20.5%, and the proportion of GDP in northern Jiangsu province increased from 21.9% to 22.8%. Accordingly, the proportion of the GDP in southern Jiangsu province to the provincial GDP has decreased from 59.9% to 56.8%. From the perspective of geographical resources and natural resources, southern Jiangsu is mainly processing and manufacturing, which belongs to a processing region, while northern Jiangsu is rich in resources and belongs to a resource-based region. In recent years, the preliminary processing mainly based on agricultural processing industry has gradually formed in northern Jiangsu, but the difficulty of industrial structure reconstruction is further deepened, which makes the regional development difference between southern Jiangsu and northern Jiangsu gradually deepened. In terms of industrial structure, in northern Jiangsu is characterized by the significant proportion of the primary industry, the weak advantage of the secondary industry and the small proportion of the tertiary industry, the advanced manufacturing and high-tech industries are less than one third of southern Jiangsu, and the economic development mode is mainly the extensive development of "high input, high consumption and low efficiency".

The analysis of spatial cold hot spots is helpful for cities to develop differentiated development strategies. For example, the hot areas should further grasp the development opportunities and improve the overall development level of cities, and the cold hot areas should further improve the upgrading of industrial structure and take the road of innovative development. In recent years, many national strategies, such as the integration of the Yangtze River Delta, the coastal development of Jiangsu Province, the construction of modernization demonstration zones in southern Jiangsu province, the "Belt and Road" initiative, and the construction of the Yangtze River Economic Belt, have all provided major strategic support for the improvement of urban resilience in Jiangsu Province.

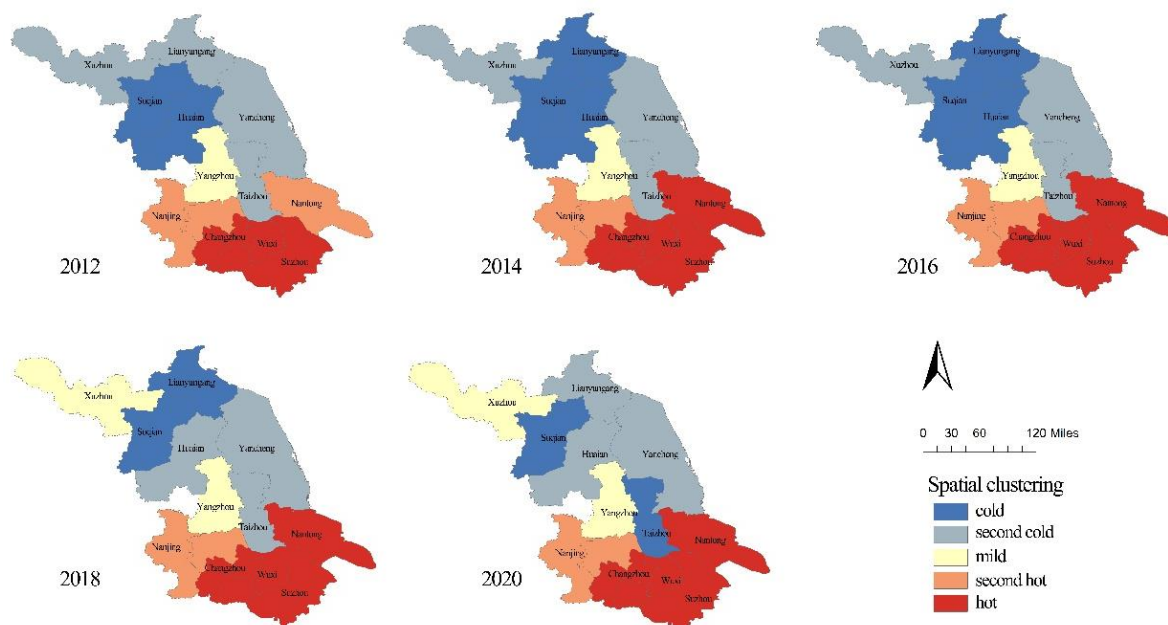


Figure 2. Spatial distribution of urban resilient cold hot spots in Jiangsu Province from 2012 to 2020(self-painted)

3.3 The Driving mechanism of the spatial differentiation of urban resilience in Jiangsu Province

3.3.1 Detection of influencing factors

The geographical detector was used to measure the influence factor of the spatial differentiation pattern of urban toughness in Jiangsu Province from 2012 to 2020. Table 3 shows that, Overall, 2012-2020 q value are large index (q value > 0.5) for industrial wastewater discharge, industrial sulfur

dioxide emissions, the tertiary industry, urban and rural residents savings balance, per capita GDP, public budget revenue, science and technology expenditure, education expenditure, built-up area, drainage length, gas penetration, urban housing area, urban civil car ownership, hospitals, universities, urban workers pension beds, urban health institutions, urban school teachers and students, basic medical insurance number, urban population. The remaining factors have a relatively small explanatory power for the spatial differentiation pattern of urban toughness.

Table 3. Detection factors influencing spatial differentiation of urban toughness in 2012-2020 Jiangsu Province(self-painted)

Index layer	q price				
	2012	2014	2016	2018	2020
The green space rate in the urban built-up area is C1 /%	0.441	0.386	0.171	0.150	0.285
Urban per capita park green area: square meters / person	0.441	0.436	0.386	0.129	0.058
Industrial waste water discharge: tons	0.673	0.814	0.818	0.801	0.782
Industrial solid waste utilization rate: %	0.522	0.137	0.038	0.101	0.099
Centralized treatment rate of sewage treatment plant: %	0.005	0.078	0.037	0.054	0.049
Industrial dust emission: tons	0.207	0.140	0.074	0.084	0.064
Industrial sulfur dioxide emissions: tons	0.595	0.740	0.536	0.570	0.507
The treatment rate of harmless household garbage: %	0.367	0.355	0.467	0.590	0.596
Tertiary industry: 100 million yuan	0.729	0.731	0.774	0.812	0.868
Outstanding savings deposits of urban and rural residents: 100 million yuan	0.707	0.729	0.763	0.810	0.852
Per capita GDP: yuan	0.596	0.859	0.808	0.822	0.828
Public finance budget revenue: 100 million yuan	0.681	0.733	0.629	0.616	0.613
Actual foreign direct investment: us \$100 million	0.099	0.015	0.022	0.287	0.279
Public finance budget expenditure: 100 million yuan	0.120	0.074	0.076	0.068	0.019
Science and technology expenditure: 100 million yuan	0.731	0.893	0.783	0.796	0.784
Education expenditure: 100 million yuan	0.715	0.748	0.782	0.822	0.828
City actual road length: km	0.069	0.173	0.162	0.451	0.463
Built-up area: square kilometers	0.529	0.548	0.530	0.538	0.749
Number of Internet users: ten thousand households	0.174	0.508	0.438	0.416	0.262
Drainage pipe length: km	0.840	0.550	0.891	0.840	0.820
Gas penetration rate: %	0.758	0.814	0.842	0.342	0.300
Urban per capita housing area: square meters	0.779	0.853	0.877	0.906	0.948
Urban civil car ownership: ten thousand	0.840	0.826	0.883	0.925	0.947
Number of hospitals:	0.836	0.893	0.789	0.873	0.847
Number of ordinary colleges of higher learning: one	0.695	0.442	0.405	0.569	0.578
Number of urban workers: people	0.836	0.826	0.842	0.857	0.902
Number of beds in urban health institutions: 1	0.751	0.816	0.828	0.834	0.947
Ordinary school teachers and students ratio: %	0.509	0.660	0.877	0.906	0.922
The number of people insured by the basic medical insurance: ten thousand people	0.840	0.826	0.743	0.857	0.828
Urban population number: ten thousand people	0.627	0.784	0.877	0.906	0.922

3.4 Formation mechanism

Based on the above results of single-factor detection and interaction factor detection, the spatial differentiation of urban resilience is the result of the interaction of economic development, social and people's livelihood, infrastructure and ecological environment (Figure 3).

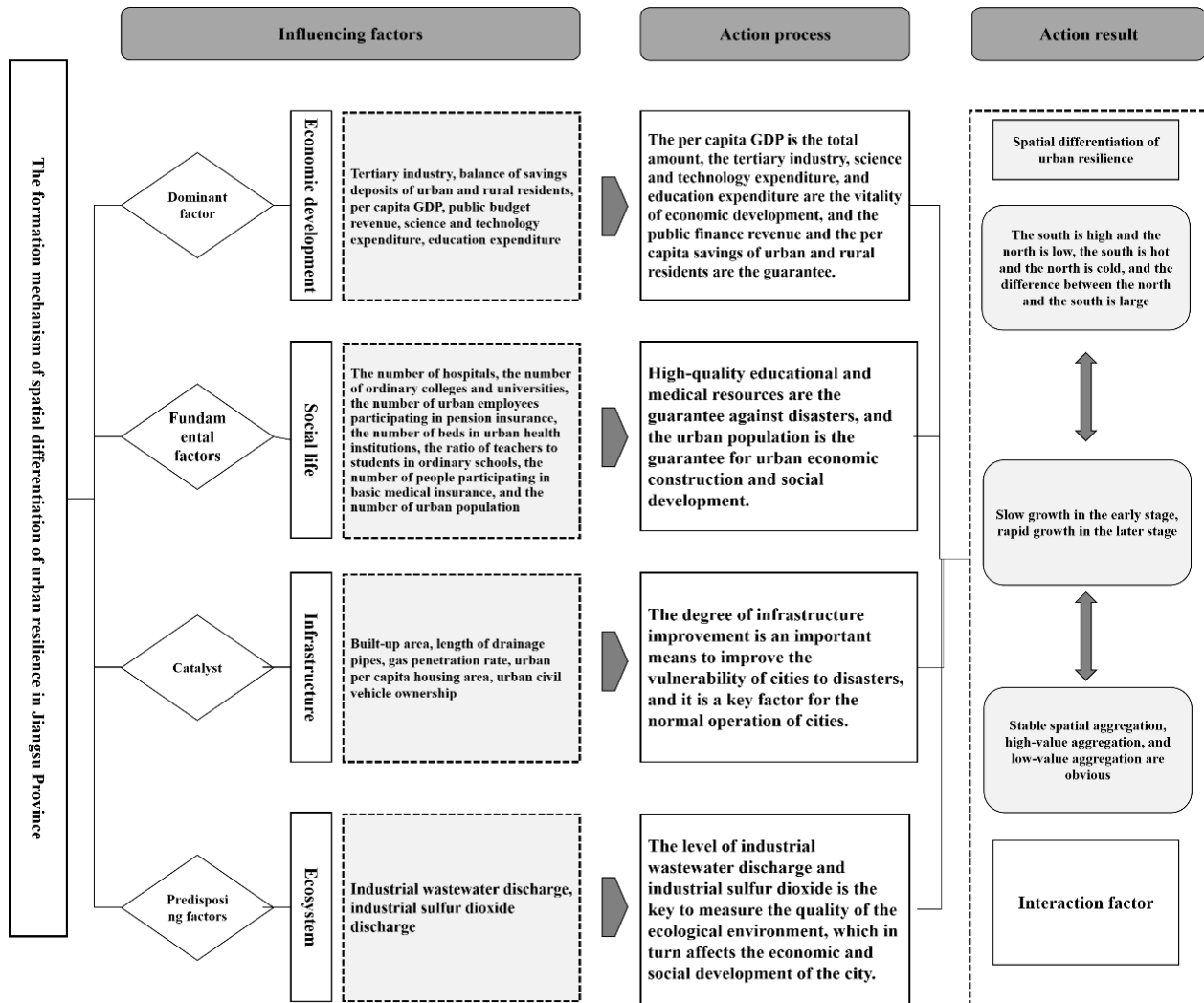


Figure 3. Mechanism of spatial differentiation of urban toughness in Jiangsu Province(self-painted)

4. Conclusion

From 2012 to 2020, the average resilience of the overall cities in Jiangsu province showed a rise, and the spatial differences between the cities gradually expanded. Southern Jiangsu (Nanjing, Suzhou) is the core area of highly toughness hot spots, with point distribution; northern Jiangsu is the low toughness cold point area, with surface distribution. From the perspective of trend evolution, 2012-2014 was a slow growth period, when the overall urban resilience index of Jiangsu Province was low, while most cities were slow; in 2014-2020, the overall resilience value of Jiangsu Province improved rapidly, and most cities entered the medium resilience stage, including Suzhou and Nanjing entered the stage of high resilience.

The spatial differentiation of urban resilience in Jiangsu province is mainly caused by the differences in economic development, social livelihood, infrastructure and ecological environment between cities. Among them, regional economic development is the leading factor, regional medical and health level and other social and human livelihood factors are the basic factors, infrastructure is the catalyst to ensure urban resilience, and ecological environment is the inducing factor causing the spatial differentiation of urban resilience. The interaction between various factors forms the spatial pattern of north and south differentiation.

This study analyzes the spatial and temporal differentiation pattern of urban resilience in Jiangsu Province, and reveals its influence mechanism from different levels, providing some reference for urban resilience research. But this paper for urban toughness index acquisition only consider the economic development, social livelihood, infrastructure, ecological environment, four levels, not the

policy between different cities, so the future in the construction of urban toughness index system should pay attention to the influence of various factors, at the same time should pay attention to the comparison between different cities, regions, and the multi-source big data mining into the study of urban toughness.

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