

Evaluation and Clustering Analysis on the Development of Urban Agglomerations in the Yangtze River Economic Belt

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Keywords: The Yangtze River Economic Belt, Chengdu Chongqing economic zone, The Yangtze River delta economic zone, Wuhan economic circle.

Abstract. Based on the urbanization development index system, the paper constructs a factor analysis and hierarchical clustering analysis model of urban economic development in the Yangtze River Economic Belt, and conducts comprehensive evaluation on the economic development of 71 cities from Shanghai, Jiangsu, Zhejiang, and Hubei province. The cities have comprehensive strength for development are Shanghai, Chongqing, Hangzhou, Suzhou, Chengdu, etc. It's better to put forward further in-depth analysis of specific conditions of these urban economic development, and strategic suggestions. Hoping that this can better promote the economic development of the Yangtze River Economic Belt urban agglomeration.

Introduction

The Yangtze River Economic Belt is an economic development corridor spanning three major areas in eastern, central and western China. To facilitate the transportation or radiation of industries' potential development, there exits Yangtze River Delta Economic Zone, Wanjiang Economic Zone, Wuhan Economic Zone and Chengdu-Chongqing Economic Zone, which play decisive roles in promoting interaction and coordinated development of eastern, central and western regions. The Yangtze River Delta Economic Zone is China's strongest comprehensive region[1], including Shanghai, Jiangsu and Zhejiang. The Pan-Yangtze River Delta Economic Zone includes the Wanjiang Economic Belt. The Wanjiang Economic Belt refers to the Anhui Economic Zone and serves as a link to expansion and development of the Yangtze River Delta economic zone [2]. Wuhan Economic Circle refers to the largest and most dense urban agglomeration centered on Wuhan. It reaches an important economic growth pole in inland areas of China[3]. Chengdu-Chongqing Economic Zone, with Chongqing and Chengdu as the center, includes the economic zone of Sichuan. In the strategic pattern of China productive forces space [4], it is important in helping the East go to the west. The research on the economic development of the Yangtze River Delta has been a hot spot for domestic scholars. However, there are relatively few economic studies over Wuhan Economic Zone and Chengdu-Chongqing Economic Zone and the Yangtze River Economic Zone. This paper establishes a factor analysis and level analysis model of urban economic development in the Yangtze River Economic Belt. By using 15 indicators, this paper analyzes development strategies of 71 cities in Shanghai, Jiangsu, Zhejiang, Hubei, Sichuan and Chongqing. Hopeto promote the development of urban agglomerations in the Yangtze River economic belt.

Construct Index System and Data Preparation

Construct Index System

In this paper, factor analysis and analytic hierarchy process (AHP) are used to evaluate. Based on the specific conditions of 71 cities in Shanghai, Jiangsu, Zhejiang, Hubei, this paper considers

economic, technological, population and education aspects. 29 items are selected as indicators of the urban economic development in the Yangtze River economic belt, as shown in Table 1.

Table 1.Evaluation Index System for the Development of 71 Cities along theYangtze River Economic Belt

X01	Urban population	X11	Total retail sales	X21	Number of doctors
X02	Population growth rate	X12	Resident savings balance	X22	Per capita road area
X03	Administrative area of land area	X13	The actual amount of foreign investment	X23	Total passenger volume
X04	Gross domestic product GDP	X14	Technology spending	X24	Total freight
X05	Investment in fixed assets	X15	Education spending	X25	The number of buses per 10,000 people
X06	Local budget revenue	X16	Number of colleges and universities	X26	Per capita green area
X07	The proportion of secondary industry GDP	X17	Hundreds of people library collection	X27	Built-up area green coverage
X08	The proportion of tertiary industry GDP	X18	Number of local phone users	X28	Environmental governance investment
X09	Number of employees	X19	Mobile phone users	X29	The total profit
X10	Total employee wages	X20	Internet users		

Data Preparation

This paper uses "China City Statistical Yearbook 2017"[5], and "Jiangsu Statistical Yearbook 2017" [6], "Sichuan Statistical Yearbook 2017" [7], "Hubei Statistical Yearbook 2017" [8] and so on.

Data Analysis

Unweighted least squares factor analysis and hierarchical cluster analysis are used to implement the Yangtze River economic belt urban data analysis. The tool is the SPSS statistical software.

Unweighted Least Squares Factor Analysis

Table 2.Common Factors of Variables

variable	initial	extract	variable	initial	extract	variable	initial	extract
X01	0.988	0.993	X11	0.998	0.985	X21	0.981	0.967
X02	0.450	0.122	X12	0.979	0.952	X22	0.735	0.415
X03	0.882	0.628	X13	0.979	0.908	X23	0.968	0.871
X04	0.998	0.985	X14	0.997	0.994	X24	0.937	0.873
X05	0.979	0.933	X15	0.998	0.986	X25	0.990	0.903
X06	0.999	0.991	X16	0.979	0.696	X26	0.483	0.159
X07	0.877	0.604	X17	0.951	0.920	X27	0.516	0.347
X08	0.928	0.999	X18	0.984	0.958	X28	0.865	0.305
X09	0.996	0.952	X19	0.991	0.942	X29	0.993	0.907
X10	0.999	0.978	X20	0.998	0.992			

Based on the data of 71 cities from 29 selected indicators, the unweighted least-squares factor analysis method is used to reduce dimensions, and the original 29 variables are reduced to 4 unobservable synthetic variables to better promote urban development problem analysis. We use SPSS19.0 to implement the development factor measurement analysis of 71 cities including X01-X29 variables. Table 2 shows the common degree of variables. The table shows that most variables have a common degree over 90%. The lower commonalities of variables are X2 and X26, which respectively represent the Population growth rate and Per capita green area. This shows that these two variables are not strong enough for urban development in these regions

Indicators X2 and X26, X27 and X28 with lower common variables are not used. Using unweighted least squares factor analysis to analyze the remaining 25 indicators. Table 4 shows results. Table 3 shows results of the KMO and Bartlett test. The KMO statistic is $0.876 > 0.7$, suitable for factor analysis. As for Bartlett's spherical test, Sig. 0.00 means that significant test counts.

Table 4 shows the eigenvalue, the variance contribution rate, the cumulative contribution rate, and the first 4 factors' initial eigenvalue is greater than 1. The cumulative variance contribution rate is 88.987%, so choose the first 4 factors to measure the level of urban development.

Table 3. KMO and Bartlett's Test

Sampling Sufficient Kaiser-Meyer-Olkin metric		0.876
Bartlett's Sphere Test	Approximate chi square	4482.413
	df	300
	Sig.	0.000

Table 4. Eigenvalue, variance contribution rate and cumulative contribution rate

factor	Initial eigenvalue			Extract square and load			Rotate squared and load		
	Total	Variance%	accumulation%	Total	Variance%	accumulation%	Total	Variance%	accumulation%
1	17.574	70.294	70.294	17.507	70.028	70.028	13.015	52.061	52.061
2	2.611	10.443	80.737	2.469	9.877	79.905	5.715	22.859	74.920
3	1.540	6.159	86.896	1.277	5.110	85.014	2.252	9.009	83.929
4	1.228	4.914	91.809	.971	3.883	88.897	1.242	4.968	88.897

Table 5. Regression method to get the normalized rotation factor score coefficient matrix

variable	factor 1	factor 2	factor 3	factor 4	variable	factor 1	factor 2	factor 3	factor 4
X01	0.046	0.182	0.625	3.473	X15	0.395	0.122	-3.864	-3.892
X03	0.122	-0.405	0.439	0.497	X16	0.227	-0.358	-1.647	-0.721
X04	-0.226	1.132	0.688	-3.635	X17	-0.254	0.401	0.217	-0.093
X05	-0.075	0.193	1.543	-1.185	X18	-0.648	0.725	-0.591	-1.808
X06	1.130	2.003	0.450	-0.953	X19	-0.482	0.551	1.341	-0.677
X07	0.117	-0.249	0.383	.658	X20	-1.622	1.567	-2.490	-2.957
X08	-0.026	-0.378	0.661	1.973	X21	-0.103	1.093	-1.131	-0.624
X09	-0.415	0.376	-1.291	-2.665	X22	-0.072	0.226	-0.117	-0.350
X10	1.591	-1.672	2.310	5.053	X23	0.073	-0.360	-0.396	0.017
X11	1.342	-2.576	2.609	5.070	X24	-0.097	-0.044	0.185	-0.535
X12	-0.535	0.361	-0.416	-.017	X25	-0.899	1.275	0.392	-1.052
X13	0.233	-0.754	0.225	1.368	X29	-0.946	0.237	-1.894	-0.899
X14	2.081	-3.873	2.367	5.378					

Table 5 shows the normalized twiddle factor score matrix obtained by using the regression method. The factor scoring functions FAC1_1, FAC2_1, FAC3_1, FAC4_1 are:

$$\text{FAC1_1} = 0.046X_{01} + 0.122X_{03} - 0.226X_{04} + \dots - 0.899X_{25} - 0.946X_{29} \quad (1)$$

$$\text{FAC2_1} = 0.182X_{01} - 0.405X_{03} + 1.132X_{04} + \dots + 1.257X_{25} - 0.946X_{29} \quad (2)$$

$$\text{FAC3_1} = 0.625X_{01} + 0.439X_{03} + 0.688X_{04} + \dots - 0.392X_{25} - 1.052X_{29} \quad (3)$$

$$\text{FAC4_1} = 3.473X_{01} + 0.497X_{03} - 3.635X_{04} + \dots - 1.052X_{25} - 0.899X_{29} \quad (4)$$

Therefore, according to the square root of the variance of each factor of extraction, the total innovation score function S1 is:

$$S1 = (13.015\text{FAC1_1} + 1.754\text{FAC2_1} + 0.839\text{FAC3_1}) / (13.015 + 5.715 + 2.252 + 1.242) \quad (5)$$

According to formula (1) ~ (5), the factor scores and total score of 71 cities in the Yangtze River economic belt could be calculated. In table 6, to the lowest rankings, Shanghai, Chongqing, Hangzhou, Suzhou, Chengdu and Wuhan ranks high. Cities rank low areezhou, Zhoushan, neijiang,

jingmen, and shiyan. The number before city is the number of city data record used for data analysis, for example, the number of data record of Shanghai is 1, other cities are similar.

Table 6. Development Score of 71 Cities in the Yangtze River Economic Zone

City	Factor1	Factor2	Factor3	Factor4	Total	City	Factor1	Factor2	Factor3	Factor4	Total
1.Shanghai	7.75	-0.79	-1.96	0.94	4.19	25.Lishui	-0.13	-1.05	0.03	1.75	-0.25
55.Chongqing	0.47	6.94	-1.59	-1.03	1.84	34.Jingzhou	-0.39	0.05	-0.82	0.96	-0.25
15.Hangzhou	1.10	0.74	1.69	1.22	1.07	43.Huaipei	0.02	-0.52	-0.71	-1.02	-0.25
6.Suzhou	1.69	-0.19	2.38	-2.00	1.07	65.Leshan	-0.10	-0.53	-0.10	-0.90	-0.25
56.Chengdu	-0.18	2.78	2.41	0.34	0.88	11.Yangzhou	-0.38	-0.36	0.24	0.65	-0.25
26.Wuhan	0.31	1.10	2.95	1.31	0.84	27.Huangshi	-0.30	-0.25	-0.11	-0.07	-0.25
16.Ningbo	1.03	0.27	1.58	-1.36	0.76	52.Bozhou	-0.37	-0.29	-0.59	1.66	-0.26
2.Nanjing	0.84	0.08	1.45	1.14	0.72	59.Luzhou	-0.35	0.15	-0.72	-0.42	-0.26
3.Wuxi	0.39	0.29	2.22	-1.56	0.44	63.Suining	-0.18	-0.07	-0.94	-0.89	-0.27
7.Nantong	0.36	-0.06	0.83	0.74	0.32	67.Meishan	-0.07	-0.43	-0.68	-0.91	-0.27
17.Wenzhou	-0.07	0.89	0.17	1.05	0.26	68.Yibin	-0.30	0.08	-0.86	-0.75	-0.29
24.Taizhou	0.19	-0.15	1.23	0.92	0.25	51.Liuan	-0.49	0.70	-1.96	0.39	-0.29
38.Hefei	0.23	-0.35	1.38	0.36	0.20	66.Nanchong	-0.34	0.53	-1.93	-0.53	-0.29
5.Changzhou	-0.12	-0.23	2.49	0.73	0.17	60.Deyang	-0.25	0.04	-0.71	-1.50	-0.29
10.Yancheng	-0.10	0.43	0.19	0.02	0.07	44.Tongling	-0.07	-0.58	-0.11	-1.70	-0.29
21.Jinhua	0.08	-0.60	0.69	1.23	0.03	29.Yichang	-0.30	-0.27	0.07	-0.99	-0.29
8.Lianyungang	-0.20	0.12	0.40	0.84	0.00	46.Huangshan	-0.37	-0.91	0.55	1.77	-0.30
4.Xuzhou	-0.70	1.35	0.43	0.33	0.00	62.Guangyuan	-0.29	-0.58	-0.22	0.76	-0.30
18.Jiaying	-0.05	-0.31	1.23	-0.70	-0.02	42.Maanshan	-0.20	-0.20	-0.07	-2.28	-0.30
39.Wuhu	0.40	-0.96	0.34	-0.94	-0.03	58.Panzhihua	-0.05	-0.41	-0.24	-2.55	-0.30
70.Dazhou	-0.11	0.38	-0.77	0.09	-0.04	45.Anqing	-0.30	-0.10	-0.72	-0.55	-0.30
30.Xiangyang	-0.21	-0.07	0.43	0.84	-0.05	36.Xianning	-0.16	-0.78	-0.50	0.71	-0.31
20.Shaoxing	-0.03	-0.20	0.20	-0.77	-0.09	47.Chuzhou	-0.35	0.20	-0.83	-1.26	-0.31
12.Zhenjiang	-0.18	-0.40	0.94	-0.04	-0.11	37.Suizhou	-0.46	-0.23	-0.13	0.41	-0.32
41.Huainan	0.20	-0.60	-0.44	-0.72	-0.12	40.Bengbu	-0.39	-0.18	-0.39	-0.42	-0.34
35.Huanggang	-0.21	0.33	-1.20	0.49	-0.13	57.Zigong	-0.34	-0.30	-0.45	-0.27	-0.34
61.Mianyang	-0.49	0.26	0.34	0.86	-0.14	49.Suzhou	-0.46	0.11	-1.21	0.38	-0.34
69.Guang an	-0.26	0.42	-1.22	0.44	-0.15	54.Xuancheng	-0.34	-0.79	0.23	0.52	-0.35
33.Xiaogan	-0.04	-0.42	-0.64	0.83	-0.15	71.Yaan	-0.10	-0.76	-0.41	-1.13	-0.36
9.Huaiian	-0.48	-0.02	0.26	1.72	-0.17	53.Chizhou	-0.24	-0.91	-0.17	0.50	-0.36
48.Fuyang	-0.53	0.49	-1.16	2.44	-0.17	28.Shiyan	-0.51	-0.23	-0.29	0.39	-0.36
14.Suqian	-0.23	0.02	-0.48	0.06	-0.18	32.Jingmen	-0.36	-0.35	-0.31	-0.71	-0.37
13.Taizhou	-0.46	0.63	-0.28	-0.85	-0.19	64.Neijiang	-0.18	-0.28	-1.13	-1.37	-0.37
19.Huzhou	-0.31	-0.28	0.64	-0.28	-0.21	23.Zhoushan	-0.47	-0.89	0.47	1.19	-0.39
22.Quzhou	-0.13	-0.67	-0.05	0.67	-0.22	31.Ezhou	-0.23	-0.47	-0.58	-1.58	-0.40
50.Chaohu	-0.12	-0.39	-0.77	0.39	-0.22						

System Hierarchical Cluster Analysis

The above runs an unweighted least-squares factor analysis on the growth of 71 cities in this economic belt and can be further analyzed by system-level cluster analysis using SPSS.

Figure 1 shows the dendrogram of 71 cities in the Yangtze River Economic Belt using system-level cluster analysis. Referring to scores of 71 cities in the Belt shown in Table 6, we find that urban development toward stop, middle and back situation is consistent. 71 cities can be grouped into three categories. The first category consists of cities with top scores, Shanghai, Chongqing, Hangzhou, Suzhou and Chengdu. Cities in the top category own the largest horizontal axis values. Horizontal axis values of cities in the middle are large, while those in the last part are smaller. The left figure shows cities and city data record numbers, which are same as what in Table 6. From the left part of the development dendrogram of 71 cities in this economic belt, we can analyze the classes that can be divided into the least difference or the smallest difference categories.

By analyzing the dendrogram of 71 cities in the Yangtze River Economic Belt clustered by system level, the results of urban clustering can be obtained as follows:

(1) In the middle group, Changzhou and Wuhan converge into a couple, Nanjing and Hangzhou converge together, Hefei, Nantong and Taizhou converge into a category, and gonging upwards to include Chengdu, and then converge into a category. Chengdu, Nanjing, Hangzhou and Hefei are both Capital cities. Changzhou, Nantong and Taizhou are famous cultural cities here. Shanghai and Chongqing first converge together as a couple as Shanghai and Chongqing are both municipalities and international metropolises. Wuxi, Suzhou and Ningbo converge into a category, which are famous huge cities in Jiangsu and Zhejiang province in the Yangtze River Delta Economic Zone.

(2) In the following group, Ma'anshan and Panzhihua are converged, and the two metallurgical towns of Tongling and Ezhou are converged. Chuzhou, Deyang and Neijiang science and technology city group are aggregated into a cluster and then aggregated into a large category. Ya'an and Meishan polymerize as a category. Yichang, Leshan, Shaoxing and Wuhu polymerize as a category. These two categories converge up into a larger category. Bengbu, Zigong and Jingmen aggregates as a category. Suining, Yibin, Luzhou, Taizhou, Anqing polymerization as a class. These two classes go upwards into a larger class; then the two larger classes up into a category.

(3) In the above group, this group is composed of three stratified groups. In the uppermost group, Nanchong and Liu'an aggregates as a couple, and Huanggang, Guang'an, Suzhou and Dazhou are aggregated into a class and then polymerize upward into a big class. In the second group, Lishui, Huangshan, Jinhua, Zhoushan, Huai'an polymerization as a class, upward with Fuyang converged as a general category. In the next group, Zhenjiang, Huzhou and Jiaxing converge into a category. Wenzhou and Xuzhou converge together into a couple. Lianyungang, Xiangyang and Mianyang are clustered into a class, and then the two groups are clustered into a larger category; Shiyan, Suizhou, Suqian, Huangshi and Yancheng clustered together as a category. Quzhou, Guangyuan, Chizhou, Yangzhou and Xuancheng polymerize as a category. Xiaogan, Xianning and Chaohu polymerize as a category, and Jingzhou and Bozhou converge into a couple, then polymerize into a larger category; then both these two groups class up into a large category.

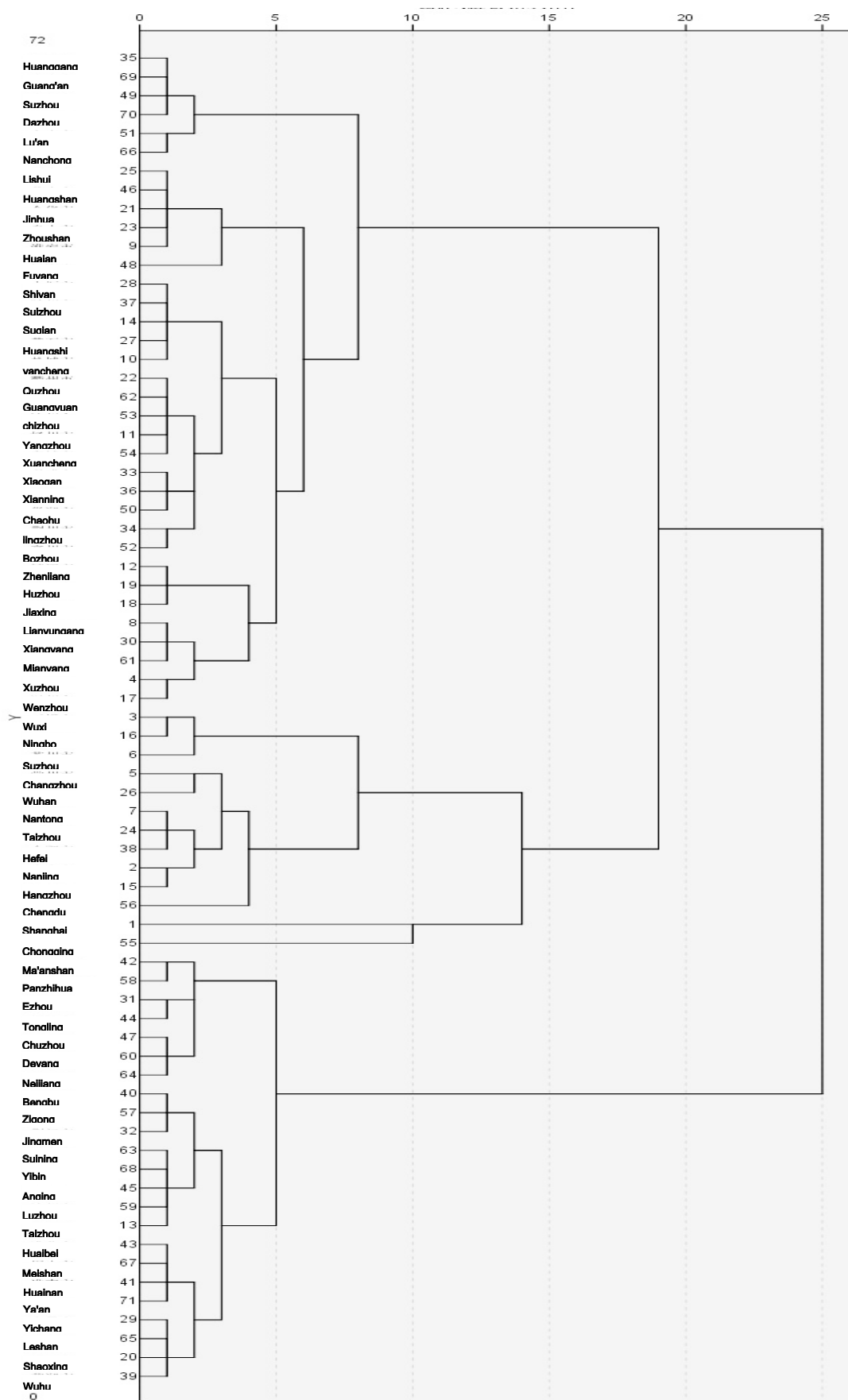


Fig 1. System-level clustering of the Yangtze River Economic Belt 71 cities dendrogram

Conclusion

In summary, the conclusions are as follows:

(1) "Two horizontal and three vertical" is the strategic layout of urbanization in our country. It develops with land-bridge passageways and two horizontal axes along the Yangtze River. Three major longitudinal urban agglomerations as a Supporting Strategic Pattern of Urbanization. The Yangtze River Economic Belt is on an important axis of urbanization strategy with development at the forefront of the country. According to the score of the previous city rankings, it's better to combine characteristics of cities to promote the development of relevant regions.

(2) In general, the economic development of the cities in the Yangtze River Delta Economic Zone is the best. Shanghai, the city with the highest city ranking, is the leading urban core of the Yangtze River Delta. It is economic, commercial, financial, information, manufacturing and transport hub in China. Nanjing is the capital of Jiangsu province, the third city of science and education in China, and an important political, military, science and education, culture, science and technology, transportation, shipping and financial center in the country. Hangzhou is the capital of Zhejiang province, the core city of Hangzhou metropolitan area. It is an important economic, scientific, educational, cultural, financial, transportation and communications center in East China. The non-provincial capital cities with the highest city rankings are mainly the cities in the Yangtze River Delta Economic Zone such as Suzhou, Ningbo, Wuxi and so on.

(3) Chengdu-Chongqing Economic Zone has developed rapidly recently. Table 6 shows that Chongqing and Chengdu rank second and fifth respectively. Chongqing locates in the upper reaches of the Yangtze River. The Yangtze River and the Jialing River surround it. Chongqing has become a national central city, the largest integrated transport hub for water and land in the western region of the country, covering economy, politics, finance, innovation, shipping, culture, science, technology, education and communication. It is an important support for leading the accelerated development of the western region and enhancing the comprehensive strength of the country in the domestic space development strategy in China. Chengdu is the capital of Sichuan Province. It is the economic, financial, commercial, cultural and scientific center of southwest China.

(4) Wuhan Economic Circle is the fastest-growing economic zone in the central region. Located in the middle and lower reaches of the Yangtze River, Wuhan ranks sixth in urban development and is the provincial capital in Hubei Province. It is the financial, commercial, transportation, scientific research, education, trade and cultural center in the central part of China. Wanjiang Economic Belt in the Midwest to undertake industrial transfer has an important strategic position, located in the Yangtze River between the Yangtze River and the Huaihe River. It is an economic, financial and transportation center of Anhui, with North-South, east and west of the regional advantages.

(5) Cities in the Yangtze River Economic Belt are representatives of urban development in eastern, central and western China. Cities in the eastern Yangtze River Delta economic zone may speed up the growth of countries. Changing the mode of economic growth with increased labor costs, attaching importance to technological innovation and industrial restructuring and continuing to strengthen advantages of economic development are crucial. Chengdu-Chongqing Economic Zone, lying in the western part of China, the urban construction of Chengdu and Chongqing with "dual-core" function can step up, speeding up development, increasing the radiation capacity and boosting the economic growth in western regions. The Wuhan economic circle, lying in the middle, has a high degree of agglomeration in second industry. These industries need supports to sustain rising. Management in cities need strengthened. Emphasis can be placed on personnel training and investment in science and technology to promote economic development in central regions.

Acknowledgement

Fund Project: The Ministry of Education Planning Fund Project (17XJA630005); Sichuan Provincial Department of Education Key Project (17SA0135).

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