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Research Article

Study on the Urban Development Level in Hubei Province Based on PCA and AHP

Yazhou Xiong, Ji Ke, Jingyuan Xing and Jingfu Chen
School of Economics and Management, Hubei Polytechnic University, Huangshi, 435003, China

Abstract: Based on the major cities in Hubei province as the research object, the comprehensive evaluation indicator system and evaluation model of the urban development level evaluation in Hubei are proposed via systems analysis. The study makes a Principal Components Analysis (PCA) to the original data by means of SPSS; Next, this study analyzes the studied data via Analytic Hierarchy Process (AHP) as well as illuminates the key principles of the AHP and that, comprehensive score and ranking of development level of the main cities in Hubei is obtained and all the regions are divided into three clusters via K-means clustering analysis; Finally, this study appraises urban development level of Hubei synthetically.

Keywords: Analytic Hierarchy Process (AHP), Principal Compound Analysis (PCA), urban development level

INTRODUCTION

The six provinces in Central China, including Shanxi, Henan, Anhui, Hubei, Hunan, Jiangxi six adjacent provinces, are located in the hinterland of China. Hubei is the center of this central region, has a unique geographical location endowed by nature. It is the point of the intersection of East and West," thoroughfare of nine provinces," and has strong ability of the economic communication, radiation, interaction. At the same time, Hubei is one of the important heavy industrial bases of China, is also one of the provinces where the country's universities and scientific research personnel gather more. The major strategic decision-making and implementation of "Rise of Central China" provides a good opportunity for the development of Hubei. Discussion on the urban development level under the background of the rise of central China in Hubei Province can provide a basis for making the urban development strategy, which has great significance.

In the past 10 years, with the development of Chinese economy, many researchers have studied the problems related to the issues from their own aspects. Deng and Yan (2006) calculated the relative efficiencies of economic development in the 17 cities of Hubei Province and analyzed the development status of the cities from the view of effectiveness with DEA method and then some improved methods were suggested. Deng (2006) analyzed the development and characteristics of urbanization in Hubei province and also looked forward to the prospects of the development of urbanization and then a few suggestions about issues on urbanization of Hubei province were provided. Zhou and Mao (2006) put forward to develop the city economy integration of Hubei as the center of Wuhan under the guidance of the scientific outlook on development and "Rise of Central China".

Generally speaking, most of researchers performed some empirical studies from the perspective of qualitative analysis and research. But the research on the urban development strategy in Hubei province still needs integrity.

Based on the previous studies, this study tries to solve these shortcomings, uses different research methods to perform comprehensive study on the urban development level in Hubei province through the statistical data and analyzes the differences among each city, which can provide some references to make the urban development strategy.

The study firstly establishes the comprehensive evaluation in dictator system evaluation system, then makes a analysis to the original data by SPSS and Principal Components Analysis (PCA), finds the weigh among the first-level indicators by Analytic Hierarchy Process (AHP) and then comprehensive score and ranking of development level of the main cities in Hubei and three clusters are obtained via K-means clustering analysis. Finally, this study appraises urban development level of Hubei synthetically, which is helpful for local economic development.

THE COMPREHENSIVE EVALUATION INDICATOR SYSTEM

At present, many scholars in the different fields have different understanding about the evaluation indicator system of the urban development level. They often establish the indicator system from their own

Corresponding Author: Yazhou Xiong, School of Economics and Management, Hubei Polytechnic University, Huangshi 435003, China

Table 1: The evaluation indicator system of the urban development level

First-level indicators	Second-level indicators	Unit	No
Economic scale and level of industrial structure (A_1)	Gross domestic product	100 million Yuan	B_1
	Local financial general budgetary revenue	100 million Yuan	B_2
	Total investment in fixed assets	100 million Yuan	B_3
	Total retail sales of consumer goods	100 million Yuan	B_4
	Per capita GDP	Yuan	B_5
	Per capita local financial general budgetary revenue	Yuan	B_6
	Proportion of primary industry in GDP	%	B_7
	Proportion of secondary industry in GDP	%	B_8
	Proportion of tertiary industry in GDP	%	B_9
Residents' lifestyle and level of quality (A_2)	Per capita total retail sales of consumer goods	Yuan	B_{10}
	Average wages of employed staff and workers	Yuan	B_{11}
	Per capita disposable income of urban residents	Yuan	B_{12}
	per capita living expenditure of urban residents	Yuan	B_{13}
	Per capita utility floor space of residential buildings	Square meter	B_{14}
	Consumer price index (preceding year = 100)		B_{15}
Level of social development (A_3)	Revenue from posts and telecommunication services	100 million Yuan	B_{16}
	Mobile telephones	10000 subscribers	B_{17}
	Number of students enrolled in institutions of higher education	10000 persons	B_{18}
	Number of scientific and technical personal	Person	B_{19}
	Total volume of collection of public libraries	10000 volumes	B_{20}
	Number of health care institutions	Unit	B_{21}
	Expenditures for culture, education, science & technology and health care	100 million Yuan	B_{22}
Level of opening up (A_4)	Actual foreign direct investment	USD 100 million	B_{23}
	Proportion of total import and export in GDP	%	B_{24}
	Proportion of international tourism foreign exchange earnings in GDP	%	B_{25}
	Number of international tourists	10000 person-times	B_{26}
Level of urbanization of the population (A_5)	Population density	Person/km^2	B_{27}
	Proportion of tertiary industry employment	%	B_{28}
	Natural population growth rate	%	B_{29}

research perspective. Due to the lack of unified definition in the connotation of urbanization and urban development, it is more difficult to make the evaluation and the evaluation results are often inconsistent. The author reviews the extensive literature study to establish the indicator system of urban development level and the methods which have been used in the study are generally divided into two categories: one is the main indicator method; the other is a composite indicator method. Because in most cases only on individual indicator is used to measure the urban development level in the main indicator method, which cannot reflect completely the situation of the urban development, the composite indicator system is more inclined to be used from the various angles and levels to evaluate and analyze the urban development level.

This study intends to establish a more scientific indicator system from the following five aspects (Ai *et al*., 2011):

- Economic scale and level of industrial structure (the economic strength, economic structure and investment scale, etc.)
- Residents' lifestyle and level of quality (residents' living environment, quality of life, etc.)
- The level of social development (the urban construction, transportation, communication level, medical treatment, education and science and technology level, etc.)
- The level of opening up (the foreign trade, international investment and foreign capital fusion, international labor service, foreign tourism, etc.)
- The level of urbanization of the population, (population density, proportion of tertiary industry employment, etc.)

Based on the principles of authenticity, reliability, accuracy, timeliness about data collection and the principles of purpose, scientific, adaptability, comparability and overall system about indicators, an evaluation indicator system which contains five first-level indicators, 29 second-level indicators have been established, which is as shown in Table 1.

THE COMPREHENSIVE EVALUATION MODEL OF URBAN DEVELOPMENT EVALUATION MODEL

The evaluation model of first-level indicators of main cities: During the calculating the development level of the first-level indicators of each city, the evaluation results are often associated with the determination of indicator weight and selection of merger rules. Therefore, the subjective factors have a great influence on the evaluation result and the numbers of each first-level indicator are different and big, which is particularly prominent. So, the principal component analysis method of economic statistics is always used to calculate the development level of each first-level indicator in the urban development evaluation system (Luo and Yang, 2010).

Principal component analysis was put forward by Hotelling in 1933 at first, whose main idea is dimension reduction. It is a multivariate statistical analysis method of converting the many indicators into a few comprehensive indicators.

The main steps are as follows (Zhang and Feng, 2004):

- To construct the sample matrix X:
  Suppose the number of evaluation object is n, the number of evaluation index is p and thus given sample values constitute the sample matrix X:

$$X_i = \{x_{i1}, x_{i2}, x_{i3}, \ldots, x_{ij}\}$$

where,
$i = 1, 2, 3, \ldots, n; j = 1, 2, 3, \ldots, p$

- To convert the element of the sample matrix:

$$y_{ij} = \begin{cases} x_{ij}, & \text{On the positive index} \\ -x_{ij}, & \text{On the negative index} \end{cases}$$

Then
$Y = [y_{ij}]_{n\times p}$

- To standardize the element of the matrix Y:

$$Z_{ij} = \frac{\left(y_{ij} - \bar{y}_j\right)}{s_j} \quad i = 1, 2, \cdots, n; j = 1, 2, \cdots, p$$

where,

$$\bar{y}_j = \frac{\sum_{i=1}^{n} y_{ij}}{n}, s_j^2 = \frac{\sum_{i=1}^{n}\left(y_{ij} - \bar{y}_j\right)^2}{n-1}$$

The standard matrix Z will be obtained:

$$Z_i = \left\{Z_{i1}, Z_{i2}, Z_{i3}, \cdots Z_{ij}\right\}$$

where,
$i = 1, 2, 3, \ldots, n; j = 1, 2, 3, \ldots, p$

- To find the correlation coefficient matrix R:
  After the standardized transformation of matrix elements, standard matrix Z can be obtained and then the correlation coefficient matrix can also be obtained through Z:

$$R = [r_{ij}]\, p \times p = \frac{Z^T Z}{n-1}$$

where,

$$r_{ij} = \frac{\sum_{k=1}^{n} z_{kj} \cdot z_{kj}}{n-1}, i, j = 1, 2, \cdots, p$$

- To find the eigenvalues:
  After solving the characteristic equation of the sample correlation coefficient matrix, we can get the corresponding the eigenvalue:

$$\left|R - \lambda I_p\right| = 0$$

Then

$$\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_p \geq 0$$

where,
R = Correlation coefficient matrix
λ_i = The eigenvalue ($i = 1, 2, 3, \cdots, p$)

- To determine the main components:

$$\frac{\sum_{j=1}^{m} \lambda_j}{\sum_{j=1}^{p} \lambda_j} \geq 0.85$$

According to the above Equation, m principal components can be determined, which will absorb 85% of the utilized information.

- To solve the unit feature vector:

$$\left\{d_1, d_2, \cdots, d_m\right\} = Z \times W$$

where,
d_i = The principal component linear combination of λ_i
i = 1, 2, 3, …, m
Z = Standardized matrix
W = Unit feature vector

- To perform the final evaluation:

$$F_i = \sum_{j=1}^{m} w_j u_j$$

where,
u_j = The score of the principal component j
w_j = The variance weight of principal component j
j = 1, 2, …, m
F = The score of the comprehensive evaluation

So the principal component analysis method is used to determine the weights of a comprehensive evaluation factor in this study, on the basis of which evaluation model will be constructed and the objective function is defined as follows:

$$P_i = \sum_{i=1}^{n_i} U_i \times V_i \tag{1}$$

where,

i = 1, 2, 3, 4, 5

P_i = The comprehensive score of the first-level indicator A_i (i = 1, 2, 3, 4, 5)

U_i = The weights of the corresponding index of the first-level indicator

V_i = Principal component scores of the corresponding Index of the first-level indicator of each city

n_i (i = 1, 2, 3, 4, 5) = The numbers of the corresponding index of the first-level indicator of each city.

Comprehensive evaluation model of urban development level in hubei province: From Eq. (1), the comprehensive development value of the first-level indicator can be calculated, on the basis of which the first-level indicators are further weighted. Because the 5 first-level indicators belong to different categories, the correlation among them is not very strong and the evaluation weights can be determined according to the important extent of factors evaluated. At the same time considering the positive and the reverse nature of the evaluation index may be different, we use the range transformation method to standardize score of first-level indicators and convert all the score of indicator into the values between 0 and 1. Therefore, it is appropriate to use analytical hierarchy process to determine weights among the first-level indicators and weighted calculation. Finally, we can use the analytic hierarchy process to establish a model, whose main steps are as follows (Duan *et al*., 2011):

- To establish the hierarchical structure model
- To construct all judgment matrices of every level
- To perform hierarchical single sorting and consistency check
- To perform total sorting of hierarchy and consistency check
- If necessary, the judgment matrix and hierarchical ranking model may be corrected and adjusted:

Evaluation model of AHP:

$$F = \sum_{i=1}^{5} W_i \times P_i \tag{2}$$

where,

F = Total index of urban development level in Hubei

W_i = Weighting value of the first-level indicator of each city

P_i = Comprehensive development level index of first-level indicator of each city

EMPIRICAL STUDY

According to the urban development theory and the actual situation, the original data corresponding to the evaluation system of the urban development level can be collected. Assuming the vector E = (E_1, E_2, …, Em_1), R = (R_1, R_2, …, Rm_2), S = (S_1, S_2, …, Sm_3), O = (O_1, O_2, …, Om_4), P = (P_1, P_2, …, Pm_5) represent respectively the vector which is composed of each first-level indicator; represent respectively the number of the second-level indicators responding to their own first-level indicator. In the course of the evaluation of 12 main cities in Hubei and the following data matrix will be obtained (Chen and Li, 2011):

$$(E_{ij}) = \begin{pmatrix} E_{11} & \cdots & E_{19} \\ \vdots & \ddots & \vdots \\ E_{m1} & \cdots & E_{m9} \end{pmatrix} (R_{ij}) = \begin{pmatrix} R_{11} & \cdots & R_{16} \\ \vdots & \ddots & \vdots \\ R_{m1} & \cdots & R_{m6} \end{pmatrix}$$

$$(S_{ij}) = \begin{pmatrix} S_{11} & \cdots & S_{17} \\ \vdots & \ddots & \vdots \\ S_{m1} & \cdots & S_{m7} \end{pmatrix} (O_{ij}) = \begin{pmatrix} O_{11} & \cdots & O_{14} \\ \vdots & \ddots & \vdots \\ O_{m1} & \cdots & O_{m4} \end{pmatrix}$$

$$(P_{ij}) = \begin{pmatrix} P_{11} & \cdots & P_{13} \\ \vdots & \ddots & \vdots \\ P_{m1} & \cdots & P_{m3} \end{pmatrix}$$

where,

$m_1 = 9$, $m_2 = 6$, $m_3 = 7$, $m_4 = 4$, $m_5 = 3$

To determine urban development level index of the first-level indicator: This study uses the descriptive command of SPSS software to standardize the original data and use the program of dimension reduction to determine the number of principal components and the contribution rate of the principal component of each first-level. And then according to Eq. (1), the score of urban development level of first-level indicator of each city will be calculated, whose results are as shown in Table 2.

To use the range transformation to process the principal component score:

The principle of the range transformation: Assuming that the maximum value and the minimum value of a row i in a matrix X = (x_{ij}) m×n is respectively $x_{j\,max}$ and $x_{j\,min}$, that is, $x_{j\,max} = \max_i\{x_{ij}\}, x_{j\,min} = \min_i\{x_{ij}\}$.

Table 2: Principal component score and rank of five first-level indicators

Municipality	A_1	Rank	A_2	Rank	A_3	Rank	A_4	Rank	A_5	Rank
Wuhan	6.2757	1	3.5013	1	6.5070	1	4.7137	1	1.0041	1
Huangshi	-0.3800	4	-0.3013	7	-0.9926	9	0.0668	4	0.3061	5
Shiyan	-0.4960	5	0.1697	2	-0.6458	8	-0.2227	5	0.0763	7
Yichang	0.1571	2	0.0920	4	-0.1821	4	0.3078	3	-0.8900	11
Xiangyang	-0.1360	3	-0.2506	5	0.0494	3	-0.5592	6	0.2694	6
Ezhou	-0.9200	11	-0.9401	12	-1.6518	12	-0.9214	11	0.8828	2
Jingmen	-0.7970	10	-0.3039	8	-1.1604	10	-0.7982	9	-1.0530	12
Xiaogan	-0.6640	7	-0.6216	10	-0.4472	6	-0.7722	8	0.5722	3
Jingzhou	-0.6750	9	-0.6894	11	0.4266	2	-0.5665	7	-0.4013	9
Huanggang	-0.6200	6	-0.2617	6	-0.2202	5	-0.9887	12	0.3465	4
Xianning	-0.6720	8	-0.5038	9	-0.4852	7	-0.8550	10	-0.3549	8
Suizhou	-1.0740	12	0.1092	3	-1.1977	11	0.5954	2	-0.7582	10

Data derive from the 2011 statistical yearbook of Hubei province; The negative values in Table 2 indicate their level is below the average level in all comparison cities, are not the true sense of the negative

Table 3: Score after the processing of the range transformation

Municipality	A_1	Score	A_2	Score	A_3	Score	A_4	Score	A_5	Score
Wuhan	6.2757	1.00	3.5013	1.00	6.5070	1.00	4.7137	1.00	1.0041	1.00
Huangshi	-0.3800	0.09	-0.3013	0.14	-0.9926	0.08	0.0668	0.19	0.3061	0.66
Shiyan	-0.4960	0.08	0.1697	0.25	-0.6458	0.12	-0.2227	0.13	0.0763	0.55
Yichang	0.1571	0.17	0.0920	0.23	-0.1821	0.18	0.3078	0.23	-0.8900	0.08
Xiangyang	-0.1360	0.13	-0.2506	0.16	0.0494	0.21	-0.5592	0.08	0.2694	0.64
Ezhou	-0.9200	0.02	-0.9401	0.00	-1.6518	0.00	-0.9214	0.01	0.8828	0.94
Jingmen	-0.7970	0.04	-0.3039	0.14	-1.1604	0.06	-0.7982	0.03	-1.0530	0.00
Xiaogan	-0.6640	0.06	-0.6216	0.07	-0.4472	0.15	-0.7722	0.04	0.5722	0.79
Jingzhou	-0.6750	0.05	-0.6894	0.06	0.4266	0.25	-0.5665	0.07	-0.4013	0.32
Huanggang	-0.6200	0.06	-0.2617	0.15	-0.2202	0.18	-0.9887	0.00	0.3465	0.68
Xianning	-0.6720	0.05	-0.5038	0.10	-0.4852	0.14	-0.8550	0.02	-0.3549	0.34
Suizhou	-1.0740	0.00	0.1092	0.24	-1.1977	0.06	0.5954	0.28	-0.7582	0.14

On the reverse indicator (the smaller it is, the more superior it is), the standardized value of the element x_{ij} is:

$$r_{ij} = \frac{x_{j\max} - x_{ij}}{x_{j\max} - x_{j\min}}$$

On the positive indicator (the bigger it is, the more superior it is), the standardized value of the element x_{ij} is:

$$r_{ij} = \frac{x_{ij} - x_{j\min}}{x_{j\max} - x_{j\min}}$$

So all elements are converted into the positive indicator and the optimal value and the worst value are 1 and 0 respectively (Xu *et al*., 2005).

Result of data processing: After processing of the range transformation, the result is in Table 3.

Comprehensive evaluation of the urban development level in Hubei province: Based on the above calculation of the principal component and range transformation, the study continues to use analytical hierarchy process to determine weights among the first-level indicators and weighted calculation. Finally, we can get the comprehensive evaluation score of development of urban development level in Hubei province:

- The process of score in Table 3:

$$f = 0.9 \times j + 0.1 \quad (3)$$

where,
j = Score in Table 3

According to the Eq. (3), values which derive from the score in Table 3 can be divided into nine classes. For example, the values between 0.1 and 0.2 belong to the first class and specific classification results are as shown in Table 4.

- **To construct all judgment matrices of every level:** According to the 1-9 scale method proposed by the mathematician T. L. Saaty in America and the rank in the Table 4; all judgment matrices of every level can be constructed. The approach is as follows: the difference of two data which belong to their own rank plus 1 is regarded as the value of a_{ij} in judgment matrix. For example: if Wuhan is in the ninth grade and Huangshi is in the first grade, the judgment value of Wuhan to Huangshi is 9, because 9 minus 1 plus 1 equals 9. On the contrary, a_{ji} is equal to the reciprocal of a_{ij}, that is to say, $a_{ji} = 1/a_{ij}$. The specific judgment matrix U_i (i = 1, 2, 3, 4, 5) is not enumerated for the relationship of length.
- **To perform hierarchical single sorting and consistency check:** By means of the software of MATLAB, the judgment matrix can be easily solved, whose eigenvectors and the largest

Table 4: Score and rank of five first-level indicators

Municipality	A_1	Rank	A_2	Rank	A_3	Rank	A_4	Rank	A_5	Rank
Wuhan	6.2757	9	3.5013	9	6.5070	9	4.7137	9	1.0041	9
Huangshi	-0.3800	1	-0.3013	2	-0.9926	1	0.0668	2	0.3061	6
Shiyan	-0.4960	1	0.1697	3	-0.6458	2	-0.2227	2	0.0763	5
Yichang	0.1571	2	0.0920	3	-0.1821	2	0.3078	3	-0.8900	1
Xiangyang	-0.1360	2	-0.2506	2	0.0494	2	-0.5592	1	0.2694	6
Ezhou	-0.9200	1	-0.9401	1	-1.6518	1	-0.9214	1	0.8828	9
Jingmen	-0.7970	1	-0.3039	2	-1.1604	1	-0.7982	1	-1.0530	1
Xiaogan	-0.6640	1	-0.6216	1	-0.4472	2	-0.7722	1	0.5722	8
Jingzhou	-0.6750	1	-0.6894	1	0.4266	3	-0.5665	1	-0.4013	3
Huanggang	-0.6200	1	-0.2617	2	-0.2202	2	-0.9887	1	0.3465	7
Xianning	-0.6720	1	-0.5038	1	-0.4852	2	-0.8550	1	-0.3549	4
Suizhou	-1.0740	1	0.1092	3	-1.1977	1	0.5954	3	-0.7582	2

Table 5: Score of hierarchical sorting, rank and classification

Municipality	A_1	A_2	A_3	A_4	A_5	Total sorting of hierarchy	Rank	Classification results
Wuhan	0.4407	0.4097	0.4200	0.4201	0.2153	0.4144	1	1
Huangshi	0.0436	0.0513	0.0316	0.0638	0.0743	0.0509	6	2
Shiyan	0.0436	0.0895	0.0585	0.0638	0.0515	0.0582	5	2
Yichang	0.0836	0.0895	0.0585	0.1037	0.0137	0.0831	2	2
Xiangyang	0.0836	0.0513	0.0585	0.0350	0.0743	0.0627	4	2
Ezhou	0.0436	0.0291	0.0316	0.0350	0.2153	0.0485	7	3
Jingmen	0.0436	0.0513	0.0316	0.0350	0.0137	0.0396	12	2
Xiaogan	0.0436	0.0291	0.0585	0.0350	0.1529	0.0472	9	3
Jingzhou	0.0436	0.0291	0.1028	0.0350	0.0259	0.0437	10	2
Huanggang	0.0436	0.0513	0.0585	0.0350	0.1080	0.0480	8	3
Xianning	0.0436	0.0291	0.0585	0.0350	0.0364	0.0400	11	2
Suizhou	0.0436	0.0895	0.0316	0.1037	0.0187	0.0640	3	2

Table 6: The indicator of average random consistency

n	3	4	5	6	7	8	9	10	11	12
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.46	1.49	1.52	1.54

Table 7: The judgment matrix of 5 first-level indicators

First-level indicators	A_1	A_2	A_3	A_4	A_5
A_1	1	3	4	2	5
A_2	1/3	1	2	1/2	3
A_3	1/4	1/2	1	1/3	2
A_4	1/2	2	3	1	4
A_5	1/5	1/3	1/2	1/4	1

of eigenvalue can be obtained. And then the hierarchical single sorting is solved, which is shown in Table 5. At last, consistency check will be done, whose equation is as follows:

$$CI = \frac{(\lambda_{\max} - n)}{(n-1)}, CR = \frac{CI}{RI}$$

where,

λ_{max} : The largest of eigenvalue
n : The rank of judgment matrix
CI : Consistency of judgment matrix deviation
CR : Random consistence rate, if $CR<0.1$, the results of hierarchical sorting will satisfy the requirement for consistency, otherwise the judgment matrix will need to be revised
RI : The average random consistency of different rank judgment matrix, whose values can be selected from Table 6. *RI*: The average random consistency of different rank judgment matrix, whose values can be selected from Table 6

The largest of eigenvalue of all judgment matrices of every level is as follows, and all the results of hierarchical sorting satisfy the requirement for consistency check:

Matrix U_1: $\lambda_{max} = 12.0422$, CI = 0.0038, CR = 0.0025<0.10
Matrix U_2: $\lambda_{max} = 12.1542$, CI = 0.0140, CR = 0.0091<0.10
Matrix U_3: $\lambda_{max} = 12.1045$, CI = 0.0095, CR = 0.0062<0.10
Matrix U_4: $\lambda_{max} = 12.1308$, CI = 0.0119, CR = 0.0077<0.10
Matrix U_5: $\lambda_{max} = 12.5784$, CI = 0.0526, CR = 0.0341<0.10

- To perform total sorting of hierarchy and consistency check:
  On the basis of the 1-9 scale method, the importance degree among the 5 first-level indicators can be judged through research and experts' evaluation. And then the judgment matrix is as follows in Table 7.

By the same method, the above judgment matrix can be calculated. And the result is as follows:

$\lambda_{max} = 5.0681$, CI = 0.0170

$CR = 0.0152 < 0.10$
$W = (0.4185, 0.1599, 0.0973, 0.2625, 0.0618)$

As is seen from above, the judgment matrix of 5 first-level indicators also satisfies the requirement for consistency check. So the weight among the first-level indicators is acceptable.

According to Eq. (2), total sorting of hierarchy and rank will be obtained, which can be seen in Table 5. Through the analysis of comprehensive score and rank of development level of twelve major cities in Hubei province, we can see that the top two of rank are Wuhan and Yichang, Jingmen and Xianning are backward.

At last, the clustering analysis can be performed by the means of K-means clustering method in SPSS software. And it is supposed that the cluster number is 3 and the convergence criteria value is 0.02, the final classification results can be shown in the last column of Table 5.

THE EVALUATION OF RESULTS

According to above statistical data and the results of the analysis by means of our system, 12 main regions of Hubei province are sorted into three clusters, of which the urban development level of Wuhan municipality and Yichang municipality is higher than the average level of the whole area; other municipalities are also a larger promotion space.

The first cluster: The first cluster includes the city of Wuhan municipality. As the capital city of Hubei province, every aspect of Wuhan municipality plays the leading role in the overall regions, whose urban development level is higher than that of other cities. At the same time, there is a big difference in the economic scale, residents' lifestyle, level of social development and so forth among other municipalities, which indicates that there exist bigger difference in the urban development level of Hubei province. By virtue of its special administrative status and a powerful economic strength, the economic radiation force of Wuhan municipality in the region cannot be ignored.

The second cluster: The second cluster includes Huangshi municipality, Shiyan municipality, Yichang municipality, Xiangyang municipality, Jingmen municipality, Jingzhou municipality, Xianning municipality and Suizhou municipality. Their situations will be introduced separately:

Urban development level of Yichang municipality is second only to Wuhan in the overall regions and every aspect of first-level indicators except the level of urbanization of the population is firmly in the forefront of the all regions. Suizhou municipality has made great achievements in the residents' lifestyle, level of quality and level of opening up and also has great potential in other aspects. The score in the economic development and level of social development of Xiangyang municipality is higher and other aspects are above average. Residents' living standards of Shiyan municipality are second only to Wuhan and other aspects have great potential. Huangshi municipality has a long history of mining, rich in cultural heritage, a solid industrial foundation, convenient geographical location. And the score of Huangshi municipality in the economic development and level of opening up is higher, but the residents' living standards and social development need to be improved. Jingzhou municipality has made outstanding achievements in the social development, whose score is second only to Wuhan municipality. Number of students enrolled in Institutions of higher education of Jingzhou municipality is 117800 persons, which is second-highest after Wuhan municipality. And number of scientific and technical personnel is 86489 persons, which is higher than Wuhan municipality. But there is still a lot of room for improvement in other aspects of Jingzhou municipality.

The third cluster: The third cluster includes EZhou municipality, Xiaogan municipality, Huanggang municipality. Population density of EZhou municipality is 680 people per square kilometer, only less than 985 people to Wuhan municipality and the natural population growth rate is also higher. Therefore, the score in population urbanization levels is higher and it is the second largest of all the regions. Five aspects of urban development of Huanggang municipality, Xiaogan municipality is similar, social development level and the quality of residents' living need to be further improved.

CONCLUSION

In this study, the method of system analysis is used to build the comprehensive evaluation indicator system and evaluation model of the urban development level evaluation in Hubei. On this basis of this, the principal component analysis, analytic hierarchy process and K-means clustering algorithm are integrated to evaluate and analyze the development level of twelve main municipalities in Hubei province. Through this research, on one hand urban development level in Hubei Province can be deeply understudied, which can provide a reliable basis for making urban development strategy of Hubei province; on the other hand, the method of data processing and analysis also has practical guiding significance to the urban development level of Hubei province.

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