

# *Evaluation of Urban Comprehensive Strength in Anhui Province Based on Factor Analysis*

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**Abstract.** The research shows that the comprehensive strength of a city is affected by many factors. This paper on the basis of the research focused on the screening process of indicators and statistical methods. First of all, starting from the research and the existing index system, establish a new evaluation index system of city development, and applied to the analysis and evaluation of 16 cities in Anhui province. Then, using the SPSS software and through the factor analysis, the status of urban development in 16 cities of Anhui Province in 2016 was analyzed and ordered. Finally, on the basis of the results, suggestions are put forward to improve the comprehensive strength of the city.

## **1. Introduction**

### **1.1 Research background**

Anhui Province is located in the east of China, covering an area of 139400 square kilometers. In 2016, according to the statistics of the National Bureau of statistics, the population of Anhui Province at the end of the year reached 61.96 million, which is an important inland province in the whole East China. On January 22, 2018, the first session of the 13th people's Congress of Anhui Province was opened in Hefei. Li Guoying, governor of Anhui Province, pointed out in his government work report that in 2017, the province's GDP was 275.187 billion yuan, an increase of 8.5% over the previous year. Among them, Hefei city has reached 721.3 billion yuan, with a per capita GDP of 92593.07 yuan. However, compared with Bengbu City, Bengbu City has only 155 billion yuan, with a per capita GDP of 47098.15 yuan, showing a significant difference. In addition to economic differences, there are also certain differences in education, culture and public facilities. Some scholars pointed out that the development and industrial structure of different regions in Anhui Province are quite different, different cities have different resource endowments, and the industrial structure is totally different. For example, Fuyang City, Bozhou City and Suzhou City in the northwest of Anhui province belong to the plain area, and the primary industry accounts for a relatively high proportion. Huainan Huaibei (coal), Tongling (copper) and Ma'anshan (steel) regions are rich in resources, and the secondary industry accounts for a relatively high proportion. Huangshan City (Huangshan) and Chizhou (Jiuhua Mountain) and other tourist attractions account for a relatively high proportion of the tertiary industry.

Table 1 GDP of Anhui Province in 2000-2016

city	2000	2005	2010	2015	2016
Hefei	446.64	1056.21	2961.67	5660.27	6274.38
Huaibei	103.02	205.14	461.64	760.39	799.03
Bozhou	153.70	235.40	512.78	942.61	1046.1
Suzhou	188.85	313.79	650.57	1235.83	1351.82
Bengbu	163.66	302.45	638.05	1253.05	1385.82
Fuyang	208.87	329.03	721.51	1267.45	1401.86
Huainan	161.48	312.20	702.93	901.08	963.84
Chuzhou	217.86	317.35	695.65	1305.70	1422.83
Liuan	149.76	264.23	580.94	1016.49	1108.15
Ma anshang	173.15	411.79	949.09	1365.30	1493.76
Wuhu	256.60	492.04	1341.12	2457.32	2699.44
Xuancheng	151.97	242.54	525.96	971.46	1057.82
Tongling	100.62	221.70	587.11	911.60	957.25
Chizhou	60.05	121.00	300.84	544.74	589.02
Anqing	218.05	375.28	868.54	1417.43	1531.18
Huangshan	79.73	158.64	309.45	530.90	576.82

## 1.2 Research purpose and significance

The development of a city includes many aspects. When evaluating it, we should also judge it from many angles. Coordinated development, mutual promotion and virtuous circle of all aspects are the primary goal of a city's development. Therefore, the main purpose of this paper is as follows: through historical data, establish a certain index system to rank and evaluate the development of 16 cities in Anhui Province, analyze the performance of each city in all aspects, and put forward targeted development suggestions for cities with weak links. The significance of this paper lies in: theoretically speaking, with the change of economic development, there are some important index systems that are no longer important in the past. The indexes that have not been introduced into the evaluation system in the past, such as environmental evaluation, innovation evaluation, etc., also play a very important role in urban strength with the attention of national policies. In a practical sense, this paper hopes to find some problems in the development of the cities ranking lower through the results of factor analysis, and provide some reference for the subsequent development.

## 2. Literature review

### 2.1 Economic indicators

Economic strength is the most important factor that affects the comprehensive strength of a city. Because of the availability of economic indicators and the difficulty of quantification, many scholars have conducted in-depth research on economic indicators.

Wu et al. [1] (2007) believed that the key to the comprehensive evaluation of regional competitiveness research lies in the establishment of a scientific, fair, objective and long-term and effective evaluation index system to a large extent and within the scope [1]. In the article about the evaluation of economic development, when establishing the index system, most of them are defined in the scope of economic development, or only in a small range to connect with the current situation of economy and add the related indexes of science and education. Bi et al. (2007) used the method of combining quantitative and qualitative analysis to evaluate the comprehensive economic strength of 11 cities in Hebei Province from four first-class indexes, namely, externalization of regional economic strength, main body of regional economic strength, quality of regional economic strength

and regional economic potential, and ten second-class indexes with 17 specific indexes. Specific indicators are shown in Table 2 [2-6].

*Table 2 Summary of evaluation economic indicators*

author	Method	Range	Specific indicators
Wang et al. (2009)	Principal component analysis cluster analysis R software	31 provinces and cities in China	GDP; consumption level of residents; fixed asset investment; total scale of construction; local fiscal revenue; local fiscal expenditure; total exports; total foreign investment; disposable income of urban households; per capita net income of rural households; freight volume
Han et al. (2012)	Linear weighting method TOPSIS Entropy method Grey correlation method Fuzzy Borda method	Seven megacities with GDP of more than 500 billion	Total economic scale index: five sub indexes, such as GDP, general budget revenue and fixed asset investment; economic quality strength index: the proportion of added value of tertiary industry, per capita GDP, total labor productivity and urbanization level; economic innovation ability index: four indexes, such as R & D input intensity of large and medium-sized enterprises; economic influence index: total import and export value of commodities Four indicators such as economic development potential index and per capita GDP development speed
Xing et al. (2007)	Principal component analysis	10 cities in Shanxi Province	Total index: GDP, total fixed asset investment, local fiscal revenue, total agricultural output value, total industrial output value, total post and telecommunications business, and total social retail goods; per capita index: GDP per capita, total fixed asset investment per capita, local fiscal revenue per capita, total agricultural output value per capita, and total industrial output value per capita.
Bi et al. (2007)	factor analysis Benchmarking analysis	11 cities in Hebei Province	Externalization of economic strength: radiation ability and absorption ability; main body of economic strength: resource wealth, market capacity and economic scale; quality of economic strength: economic structure and economic efficiency; potential of economic strength: innovation ability, successful transformation and financial finance.
Cheng et al. (2012)	principal component analysis Spatial expression	17 cities in Anhui Province	Comprehensive economic strength: regional per capita GDP, total retail sales of consumer goods for human settlements, disposable income of urban residents, per capita net income of rural residents, proportion of output value of tertiary industry in GDP (%); foreign trade development: total import goods (USD 10000), total export goods (USD 10000), actual foreign investment (USD 10000); science and education: Science and technology expenditure (USD 10000 Yuan), per capita education expenditure (yuan); infrastructure: beds per 10000 people, urban road area per capita (square meters), public transport vehicles per 10000 people; resources and environment: daily living water per capita (liter), park green area per capita (square meters)

## 2.2 Analysis method and innovation

The comprehensive strength of a city deals with the economic strength as well as education, science and technology. The evaluation method of the city's competitiveness is constantly improving. The specific methods are as follows:

Table 3 Comprehensive evaluation method

Author	Method
Wang et al. (2009)	Principal component analysis Cluster analysis R software
Han et al. (2012)	Linear weighting method TOPSIS Entropy method Grey correlation method Fuzzy Borda method
Bi et al. (2007)	Factor analysis Benchmarking analysis Principal component analysis
Cheng et al. (2012)	Spatial expression
Qian et al. (2010)	Data envelopment analysis
Huo et al.(2010)	Data envelopment analysis AHP
Wang et al. [7] (2010)	Artificial neural network

### 2.3 Literature review and evaluation

In terms of economic indicators: according to the research review in recent years, the indicators of Economic Research of provinces, cities and regions nationwide (Wang et al., 2009; Han et al., 2012) are relatively comprehensive [3-4], from GDP to fiscal revenue expenditure, from R & D investment to GDP development speed. The research focused on specific provinces and cities (Xing et al., 2007; Bi et al., 2007; Cheng et al., 2012) includes not only classic economic analysis indicators, but also indicators added according to different regional characteristics, such as Cheng et al. (2012) adding per capita urban road area to the evaluation of Anhui Province.

Analysis method and Innovation: Based on the existing research, the combining methods used in the evaluation of urban competitiveness in China mainly include principal component analysis, factor analysis, regression analysis, data envelopment analysis (DEA), analytic hierarchy process (AHP), entropy method and artificial neural network method.

### 2.4 Construction and analysis of urban comprehensive strength index system

Based on the analysis and summary of the previous studies, it can be found that most of the scholars are consistent in the overall framework of the current urban comprehensive strength index system. Therefore, based on the comprehensiveness of indicators and the availability of data, the indicator system of urban comprehensive strength should include the following aspects: the current economic strength of the city, the capacity of sustainable development of the city, three first-class indicators of the city charm index, six second-class indicators, and 15 third-class indicators (Table 3). The data is from the 2016 annual data published by the website of Anhui Provincial Bureau of Statistics (Anhui statistical yearbook, 2017), and the factor analysis method is used [8-10].

Table 4 City comprehensive strength index system

Index system of urban comprehensive strength	Current economic strength	Economic aggregate	GDP (x1)
		Quality of economic development	Fixed assets investment(x2)
			Output value of tertiary industry (x3)
			Per capita disposable income (x4)
	Total retail sales of consumer goods (x5)		
	Sustainable development capacity	Opening degree	Total import and export (x6)
			Foreign direct investment (X7)
		Investment in talent development	Number of research institutions (x8)
			Number of students in Colleges and universities (x9)
	City charm index	Talent attraction	Highway passenger volume (X10)
			Total floating population (X11)
		Capital attraction	Actual utilization of foreign investment (X12)

### 3. Data processing and method application

#### 3.1 Introduction to factor analysis method

This paper mainly uses spss25.0 to realize data analysis and processing. Use factor analysis method to analyze the data, and the main processing process is shown in the figure below:

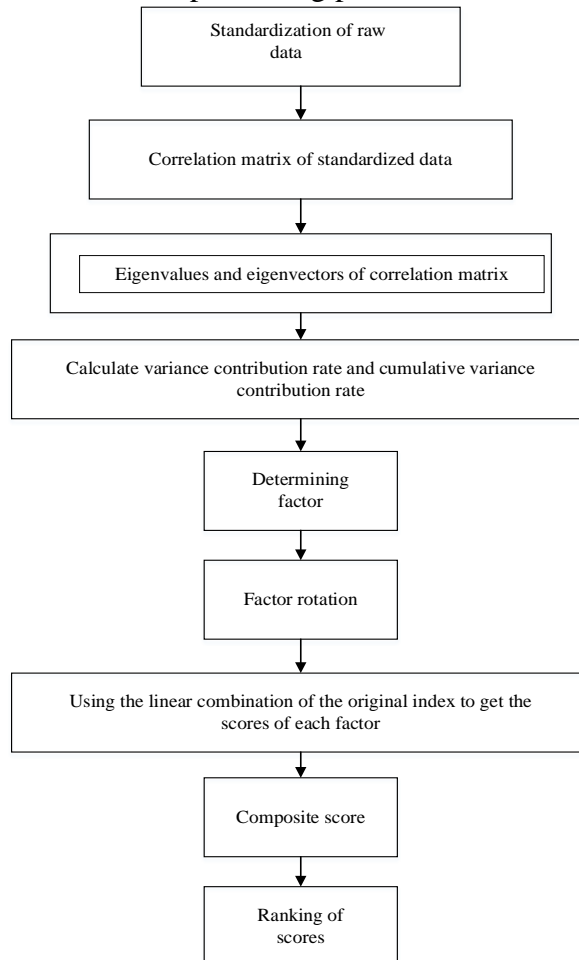


Figure. 1 Factor analysis process chart

Among them, the standardization of original data is to eliminate the difference in quantity and dimension between variables. In the determination factor, the cumulative variance contribution rate of the first m principal components shall not be less than 80%, and the factor score shall be calculated by regression estimation method. Finally, the variance contribution rate of domestic capital shall be taken as the weight, and the comprehensive evaluation objective function shall be obtained by the linear combination of each factor, so as to obtain the score rank of each prefecture level city.

### 3.2 Factor analysis process

#### 3.2.1 KMO and Bartlett test

Firstly, using SPSS, kmo and Bartlett tests are carried out on the original data to test whether there is correlation between the data, which is suitable for factor analysis. The results are as follows:

*Table 5 KMO and Bartlett test*

KMO number of sampling suitability		.801
Bartlett sphericity test	Approximate Chi Square	381.760
	free degree	66
	Saliency	.000

It can be seen from table 5 that the value of KMO is 0.801, greater than 0.7 (generally 0.7), and the value of chi square test is  $0.000 < 0.1$ , indicating that the variables are not independent of each other, that is, the original variables can be factor analyzed.

*Table 6 Common Factor Variance*

	initial	extraction
GDP (x1)	1.000	.990
Fixed assets investment (x2)	1.000	.988
Output value of tertiary industry (x3)	1.000	.989
Per capita disposable income (x4)	1.000	.599
Total retail sales of consumer goods (x5)	1.000	.989
Total import and export (x6)	1.000	.965
Foreign direct investment (X7)	1.000	.942
Number of research institutions (x8)	1.000	.914
Number of students in Colleges and universities (x9)	1.000	.965
Highway passenger volume (X10)	1.000	.935
Total floating population (X11)	1.000	.760
Actual utilization of foreign investment (X12)	1.000	.962

The main component analysis method is used to extract, from the common factor variance, the commonality of each variable is high, which shows that most of the information in the variable can be extracted by the factor, which shows that the result of factor analysis is effective.

#### 3.2.2 Calculate the eigenvalue, variance contribution rate and common factor of correlation matrix

The data are calculated by SPSS software, and the total variance is explained as follows by principal component analysis:

Table 7 Explanation of Total Variance

component	Total	Variance percentage of initial eigen value	Cumulation %	Total	Extract load square sum variance percentae	Cumul--ation%	Total	Percentage of variance of square sum of rotating load	Cumulation %
1	9.402	78.348	78.348%	9.402	78.348	78.348	9.374	78.116	<b>78.116</b>
2	1.596	13.304	91.652	1.596	13.304	91.652	1.624	13.536	<b>91.652</b>
3	.637	5.312	96.964						
4	.129	1.077	98.041						
5	.117	.971	99.012						
6	.054	.454	99.466						
7	.034	.280	99.746						
8	.016	.131	99.877						
9	.008	.068	99.945						
10	.005	.038	99.982						
11	.002	.016	99.999						
12	.000	.001	10.000						

From the results of total variance interpretation, we can see that the total variance explained by the first two factors accounts for more than 91% of the total variance, which can basically reflect the information of the original 12 evaluation indexes. So we extract the first two factors as common factors.

### 3.2.3 Result analysis

In this paper, the maximum variance orthogonal rotation method will be used to make the square value of the factor conform to differentiate into two directions: 0 and 1, that is, each variable has a large load on a common factor, while the load on other common factors is small, so the practical significance of the factor is observed.

Table 8 Composition Matrix after Rotation

	1	2
GDP (x1)	<b>.995</b>	-.023
Fixed assets investment (x2)	<b>.987</b>	-.122
Output value of tertiary industry (x3)	<b>.994</b>	.017
Per capita disposable income (x4)	.521	<b>-.572</b>
Total retail sales of consumer goods (x5)	<b>.986</b>	.113
Total import and export (x6)	<b>.966</b>	-.182
Foreign direct investment (X7)	<b>.968</b>	-.069
Number of research institutions (x8)	<b>.953</b>	-.072
Number of students in Colleges and universities (x9)	<b>.980</b>	-.067
Highway passenger volume (X10)	<b>.715</b>	.650
Total floating population (X11)	-.051	<b>.870</b>
Actual utilization of foreign investment (X12)	<b>.963</b>	-.190

From the rotated component matrix, it can be seen that public factor F1 has obvious explanatory significance in terms of regional GDP, output value of the tertiary industry, total import and export, foreign direct investment, number of research institutions, highway passenger traffic volume, and

actual utilization of foreign capital, and is an index to evaluate regional development strength. F2 has obvious significance in explaining the per capita disposable income and the total number of floating population, and it is an index to evaluate the people's life in the region.

*Table 9 Component score coefficient matrix*

	F1	F2
GDP (x1)	.107	.017
Fixed assets investment (x2)	.103	-.046
Output value of tertiary industry (x3)	.107	.020
Per capita disposable income (x4)	.039	-.341
Total retail sales of consumer goods (x5)	.111	.113
Total import and export (x6)	.099	-.084
Foreign direct investment (X7)	.103	-.013
Number of research institutions (x8)	.101	-.016
Number of students in Colleges and universities (x9)	.104	-.011
Highway passenger volume (X10)	.098	.428
Total floating population (X11)	.022	.542
Actual utilization of foreign investment (X12)	.098	-.089

According to the contribution rate of each common factor, this paper obtains the comprehensive factor score formula, which is  $F = 0.78116 * F1 + 0.13304 * F2$ . The comprehensive factor scores of each city are calculated. The comprehensive factor scores of the samples are calculated by regression estimation method, and the regional comprehensive strength of 16 cities in Anhui Province is obtained. According to this, the cities are sorted. SPSS software can directly calculate factor scores, and the results are as follows:

*Table 10 Ranking of Comprehensive Scores*

City	F1	F2	Total Score	ranking
Hefei	3.55387	-0.0536	2.76901	1
Huaibei	-0.64605	-0.92485	-0.62771	16
Bozhou	-0.43729	0.26495	-0.30634	12
Suzhou	-0.3187	0.46064	-0.18767	9
Bengbu	-0.01768	-0.25219	-0.04736	6
Fuyang	-0.01159	2.84348	0.369243	2
Huainan	-0.37736	0.47408	-0.23171	10
Chuzhou	-0.05072	-0.02144	-0.04247	5
Liuan	-0.26039	0.92977	-0.07971	7
Ma anshang	-0.00675	-1.26606	-0.17371	8
Wuhu	0.62453	-0.94482	0.362159	3
Xuancheng	-0.29808	-0.42981	-0.29003	11
Tongling	-0.37753	-1.09087	-0.44004	13
Chizhou	-0.69285	-0.63107	-0.62518	15
Anqing	-0.10556	0.59129	-0.00379	4
Huangshan	-0.57787	0.05051	-0.44469	14

From table 8, it can be concluded that Hefei, as the capital city of Anhui Province, is located in



the middle of Anhui Province, with relatively superior geographical location and resources, and excellent performance in public factor F1, which shows that Hefei has a strong economic strength, medium performance in public factor F2, and people's living standards as the capital city need to be improved. Fuyang City has a high score on the public factor F2. As a prefecture level city with the largest floating population, it shows that the economic development result of Fuyang area benefits the people very well. Compared with that, Ma'anshan City is strengthening the improvement of people's life. Suzhou, the last ranked City, needs to improve its economic strength and people's living standards due to the relative lack of resources.

#### 4. Summary and suggestions

In this paper, the comprehensive strength of 16 cities in Anhui Province is studied. On the one hand, the existing literature is reviewed. From the perspective of urban competitiveness, the evaluation indexes of 16 cities in this paper are established considering the current situation of Anhui Province and the availability of statistical data. The indexes include the current economic strength, the sustainable development ability and the charm index of the city. Using statistical analysis software SPSS, data processing and factor analysis method, two public factors are extracted from 12 sub indicators, which are: evaluating the strength of economic development, the strength of development results benefiting the people and sustainable development, and evaluating the performance of different cities in these three aspects.

The evaluation results are generally consistent with the previous studies, and Hefei, the provincial capital, takes the first place. From the ranking, we can find that economic factors still occupy a very important proportion in the economic evaluation of a region or city, and the development differences between regions still exist objectively.

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