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Evaluation and Regional Difference Analysis of Coupling Development of Higher Education and Regional Economy Based on Factor Analysis-take Anhui Province for Example

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Abstract: *Higher education and regional economic development must have a certain relationship, and they are also important indicators of regional development evaluation. The degree of coupling coordination between higher education and regional economy also affects the development of regional economy. The results show that: in the factor analysis, regional comprehensive strength and teacher-student ratio determine the quality level of higher education; Economic structure, economic vitality, economic quality and social factors are the important forces affecting regional economy. At the same time, after comprehensive analysis, except Hefei, Wuhu, Chizhou, the other 11 cities all have the problem of poor coupling coordination to varying degrees. Low quality coupling and other adverse development factors also appear in Anhui province. In the future, Anhui province still needs further reform and development in higher education and regions.*

Keywords: *Higher Education; Regional Economy; Coupling Coordination*

1. Theory and Method

1.1 Method Principle

As a data simplification technique, factor analysis can integrate multiple variables into a few factors to analyze the original variables. That is, a few independent non-observational variables are used to reflect most of the important information given in the original data.

1.2 Theoretical Model

Suppose P has the original variables $Z_1 \ldots Z_m$, and the mean value of each variable is 0 and the standard deviation is n. Now, each original variable is represented by a linear combination of P common factors F_1, F2… Fp, so the basic model of factor analysis is as follows:

$$\begin{cases} Z_1 = a_{11}F_1 + a_{12}F_2 + \cdots + a_{1p}F_p + c_1U_1 \\ Z_2 = a_{12}F_1 + a_{22}F_2 + \cdots + a_{2p}F_p + c_2U_2 \\ \cdots \\ Z_m = a_{m1}F_1 + a_{m2}F_2 + \cdots + a_{mp}F_p + c_mU_m \end{cases} \quad (1)$$

This is expressed in matrix form as$Z = AF + CU$.

2. Construction of Index System

2.1 Construction Principles

In order to accurately quantify the construction level of higher education in Anhui Province, this paper follows five principles of scientificness, relevance, integrity, flexibility and practicability when choosing influencing factors. Scientific means that the data source is real and reliable, for example, the

ISSN 2616-7433 Vol. 4, Issue 1: 93-100, DOI: 10.25236/FSST.2022.040115

data source is the official government statistical website, to ensure the final evaluation results are true and reliable; Correlation refers to that in the case of complete selection of various indicators, the indicators with correlation are retained and the indicators with very low correlation are eliminated to ensure that the model has certain pertinence after establishment. Integrity means that the selected indicators are enough to cover the core indicators to measure the level of education quality in Anhui Province; Flexibility refers to the selection of representative indicators with local characteristics according to the local characteristics of different regions. Anhui Province, as a city in central China, has a certain lag in the development of its educational level, so the selection of indicators must conform to the local educational level characteristics. Practicability means that the mathematical model finally established can reasonably evaluate the quality of education and teaching in Anhui Province with certain practical significance and provide feasible suggestions for the development of higher education in Anhui Province. The above five principles are the basis of the index system construction in this paper, and also provide guarantee for the model construction.

2.2 Objects of Evaluation

In this paper, we study the target for the comprehensive evaluation of higher education quality level in Anhui province so select subordinates with 16 cities in Anhui province as the object of evaluation, including in Hefei, Huaibei, Bozhou, Suzhou, Bengbu, Fuyang, Huainan, Chuzhou, Luan, Maanshan, Wuhu, Xuancheng, Tongling, Chizhou, Anqing, Huangshan..

2.3 Assessment Indicator System

Table 1: Assessment indicator system

variable	Level indicators	Secondary indicators	Indicators in accordance with
Higher education	Overall size	Years of education per capita	X_1
		Number of ordinary institutions of higher learning	X_2
		Number of graduates from higher education	X_3
		Higher education per 100000 people	X_4
	faculty	Number of teachers transferred to higher education	X_5
		The proportion of the teachers and students	X_6
	Scientific and technological achievements	Number of scientific papers published	X_7
		Full-time research fellow	X_8
		Number of patents granted	X_9
	Fund investment	Investment in scientific research funds for institutions of higher learning	X_{10}
		Educational funds expenditure	X_{11}
Regional economy	Economy of scale	GDP	Y_1
		Fiscal revenue	Y_2
	Economic structure	Proportion of secondary industry	Y_3
		Proportion of tertiary industry	Y_4
		Investment in fixed assets increased	Y_5
	Economic quality	GDP per capita	Y_6
		Per capita disposable incom	Y_7
	Economic vitality	Number of the enterprise	Y_8
		Loan amount of financial institution	Y_9
		Total retail sales of consumer goods	Y_{10}

3. Evaluation of Higher Education Quality and Economic Development Level in Anhui Province

3.1 Comprehensive Evaluation of Higher Education Quality in Anhui Province

3.1.1 Applicability Test of the Model

In this paper, there are many variables and data selected to study the quality level of higher education in Anhui Province. If the correlation between variables is insufficient, factor analysis cannot be carried out. Therefore, in order to verify the applicability of factor analysis to the indicator group, KMO and Bartlett tests were performed on each indicator in advance. The test results are shown in Table 1 below: The moderation test value of KMO is 0.733>0.5, and the Bartlett&apos's sphericity test value is Sig. is 0<0.01, rejecting the null hypothesis that the correlation coefficient matrix is the identity matrix. It indicates that there is a correlation between variables and factor analysis can be

ISSN 2616-7433 Vol. 4, Issue 1: 93-100, DOI: 10.25236/FSST.2022.040115

carried out.

Table 2: KMO and Bartlett tests

KMO		0.733
Sphercity test of Bartlett	The approximate chi-aquare	322.007
	df	55
	Sig.	0.000

3.1.2 Factoring

According to the principle that the cumulative variance contribution is greater than 85%, two common factors can be extracted. The results show that the eigenvalue of the first two factors is greater than 1, the variance contribution rate of the first factor is 72.121%, the variance contribution rate of the second factor is 13.728%, and the cumulative variance contribution rate of the first three factors is 85.849%>85%. Therefore, these three factors can represent 85.849% of all index information, and also indicate that these two factors are sufficient to explain the quality level of higher education in Anhui Province.

Table 3: Total variance of interpretation

Initial eigenvalue			Extract the sum of aquares and load			Rotate squares and load		
sum	variance%	accumulate %	sum	variance%	accumulate %	sum	variance%	accumulate %
8.435	76.686	76.686	8.435	76.686	76.686	7.933	72.121	72.121
1.008	9.163	85.849	1.008	9.163	85.849	1.510	13.728	85.849
0.723	6.573	92.422						
0.518	4.707	97.129						
0.182	1.655	98.783						
0.067	0.605	99.389						
0.033	0.296	99.685						
0.025	0.229	99.914						
0.007	0.067	99.981						
0.002	0.018	99.999						
0.000	0.001	100.000						

As can be seen from Table 4, principal component 1 is mainly composed of variables X1, X2, X3, X4, X5, X7, X8, X9, X10 and X11. These variables all reflect the comprehensive strength of education quality in Anhui Province and are set as the common factor F1. Principal component 2 is mainly composed of variable X6, which mainly reflects the proportion of teachers and students, and is set as a common factor F2.

Table 4: Rotational component matrix

variable	ingredient	
	1	2
X_1	0.772	0.370
X_2	0.974	0.136
X_3	0.980	0.158
X_4	0.843	0.137
X_5	0.977	0.178
X_6	-0.101	-0.971
X_7	0.881	0.337
X_8	0.978	0.089
X_9	0.981	0.111
X_{10}	0.702	0.424
X_{11}	0.750	0.151

3.1.3 Modeling

$$F_1 = 0.056X_1 + 0.143X_2 + 0.139X_3 + 0.120X_4 + 0.135X_5 + 0.195X_6 + 0.083X_7 + 0.154X_8 + 0.150X_9 + 0.032X_{10} + 0.100X_{11} \quad (2)$$

$$F_2 = 0.176X_1 - 0.087X_2 - 0.067X_3 - 0.057X_4 - 0.049X_5 - 0.884X_6 + 0.121X_7 - 0.131X_8 - 0.112X_9 + 0.242X_{10} - 0.024X_{11} \quad (3)$$

ISSN 2616-7433 Vol. 4, Issue 1: 93-100, DOI: 10.25236/FSST.2022.040115

Table 5: Component score coefficient matrix

variable	ingredient	
	1	2
X_1	0.056	0.176
X_2	0.143	-0.087
X_3	0.139	-0.067
X_4	0.120	-0.057
X_5	0.135	-0.049
X_6	0.195	-0.884
X_7	0.083	0.121
X_8	0.154	-0.131
X_9	0.150	-0.112
X_{10}	0.032	0.242
X_{11}	0.100	-0.024

In order to facilitate subsequent research, this paper defined the comprehensive score of factor analysis, namely the quality level of higher education in Anhui Province, as F, combined with the two common factors F1 and F2 obtained from the factor analysis, established the linear function relationship between F and F1 and F2, and obtained the comprehensive score of higher education quality in various cities of Anhui Province:

$$F = (0.72121F_1 + 0.13728F_2)/0.85849 \quad (4)$$

Then, the comprehensive score of higher education quality in each city is obtained according to the calculation formula F, F1 and F2, as shown in Table 6 below:

Table 6: Overall scores and rankings for the quality of higher education

city	F_1	F_2	F	sort
He fei	3.63065	0.18872	3.08	1
Wu hu	0.49694	0.42367	0.49	2
Chou zhou	-0.16764	0.75487	-0.02	3
Ma an shan	-0.17828	0.83583	-0.02	4
Huai bei	-0.32796	1.45112	-0.04	5
An qing	-0.18144	0.00453	-0.15	6
Beng bu	-0.32393	0.58044	-0.18	7
Fu yang	-0.35904	0.50072	-0.22	8
Huai nan	-0.37993	0.3612	-0.26	9
tongling	-0.33401	0.06522	-0.27	10
Lu an	-0.28949	-0.33061	-0.3	11
Su zhou	-0.38151	-0.02312	-0.32	12
Xuan cheng	0.12893	-2.86644	-0.35	13
Chi zhou	-0.2796	-1.47411	-0.47	14
Huang shan	-0.55841	-0.03903	-0.48	15
Bo zhou	-0.49529	-0.43301	-0.49	16

3.2 Comprehensive Evaluation of the Economic Development Level of Anhui Province

3.2.1 Applicability test of the model

Firstly, in order to verify the applicability of factor analysis to the indicator group, KMO and Bartlett tests were performed on each indicator in advance. The test results are shown in Table 7 below: The moderation test value of KMO is 0.539>0.5, and the Bartlett's sphericity test value is Sig. is 0<0.01, rejecting the null hypothesis that the correlation coefficient matrix is the identity matrix. It indicates that there is a correlation between variables and factor analysis can be carried out.

Table 7: KMO and Bartlett tests

KMO		0.539
Sphercity test of Bartlett	The approximate chi-aquare	219.111
	df	45
	Sig.	0.000

3.2.2 Factoring

The results show that the eigenvalue of the first three factors is greater than 1, the variance contribution rate of the first factor is 47.680%, the variance contribution rate of the second factor is 23.619%, the variance contribution rate of the third factor is 12.537%, and the cumulative variance contribution rate of the first three factors is 83.836%. Therefore, these three factors can represent 83.836% of all index information, indicating that these three factors are sufficient to explain the economic development level of Anhui Province.

ISSN 2616-7433 Vol. 4, Issue 1: 93-100, DOI: 10.25236/FSST.2022.040115

Table 8: Total variance of interpretation

Initial eigenvalue			Extract the sum of aquares and load			Rotate squares and load		
sum	variance%	accumulate%	sum	variance%	accumulate%	sum	variance%	accumulate %
5.036	50.360	50.360	5.036	50.360	50.360	4.768	47.680	47.680
2.292	22.919	73.279	2.292	22.919	73.279	2.362	23.619	71.300
1.056	10.557	83.836	1.056	10.557	83.836	1.254	12.537	83.836
0.863	8.626	92.462						
0.653	6.528	98.990						
0.059	0.594	99.584						
0.020	0.196	99.780						
0.012	0.122	99.902						
0.008	0.076	99.978						
0.002	0.022	100.000						

It can be seen from Table 9 that principal component 1 is mainly composed of variables Y1, Y2, Y4, Y8 and Y10. These variables all reflect economic structure and regional vitality and are set as common factor F1. Principal component 2 is mainly composed of variables Y3, Y6 and Y7, which mainly reflects the level of economic quality and is set as a common factor F2. Principal component 3 is mainly composed of variables Y5 and Y9, which mainly reflect social assets and is set as common factor F3.

Table 9: Rotational component matrix

variable	ingredient		
	1	2	3
Y_1	0.939	0.252	-0.069
Y_2	0.924	0.313	-0.086
Y_3	-0.423	0.860	0.130
Y_4	0.757	-0.343	-0.093
Y_5	0.022	-0.001	0.840
Y_6	0.414	0.858	0.009
Y_7	0.478	0.754	0.135
Y_8	0.968	0.087	-0.109
Y_9	-0.188	0.142	0.689
Y_{10}	0.952	0.102	-0.076

3.2.3 Modeling

$$F_1 = 0.191Y_1 + 0.180Y_2 - 0.164Y_3 + 0.200Y_4 + 0.101Y_5 + 0.021Y_6 + 0.059Y_7 + 0.208Y_8 + 0.021Y_9 + 0.207Y_{10} \quad (5)$$

$$F_2 = 0.043Y_1 - 0.075Y_2 + 0.425Y_3 - 0.217Y_4 - 0.123Y_5 + 0.265Y_6 + 0.292Y_7 - 0.032Y_8 - 0.015Y_9 - 0.026Y_{10} \quad (6)$$

$$F_3 = 0.010Y_1 - 0.016Y_2 - 0.058Y_3 + 0.054Y_4 + 0.0738Y_5 - 0.068Y_6 + 0.064Y_7 + 0.002Y_8 + 0.561Y_9 + 0.026Y_{10} \quad (7)$$

Table 10: Component score coefficient matrix

variable	ingredient		
	1	2	3
Y_1	0.191	0.043	0.010
Y_2	0.180	0.075	-0.016
Y_3	-0.164	0.425	-0.058
Y_4	0.200	-0.217	0.054
Y_5	0.101	-0.123	0.738
Y_6	0.021	0.365	-0.068
Y_7	0.059	0.292	0.064
Y_8	0.208	-0.032	0.002
Y_9	0.021	-0.015	0.561
Y_{10}	0.207	-0.028	0.026

In order to facilitate the follow-up study, this paper defined the comprehensive score of factor analysis, namely the economic development level of Anhui Province, as F, and established the linear function relationship between F and F1, F2 and F3 based on the three common factors F1, F2 and F3 obtained from factor analysis, so as to obtain the comprehensive score of economic development level of various cities in Anhui Province:

$$F = (0.47680F_1 + 0.23619F_2 + 0.12537F_3)/0.83836 \quad (8)$$

Then, according to the calculation formula of F, F1, F2 and F3, the comprehensive score of the economic development level of each city is shown in Table 11 below:

ISSN 2616-7433 Vol. 4, Issue 1: 93-100, DOI: 10.25236/FSST.2022.040115

Table 11: Regional economy comprehensive score and ranking

city	F_1	F_2	F_3	F	sort
He fei	3.54224	0.48496	-0.33607	2.1	1
Wu hu	0.25577	1.57765	-0.0601	0.58	2
Ma an shan	-0.23784	1.75638	1.12944	0.53	3
Huai bei	-0.08277	-0.66041	2.7588	0.18	4
Beng bu	-0.1	-0.03282	0.82843	0.06	5
Chou zhou	-0.44312	0.97979	0.22146	0.06	6
Fu yang	0.30027	-1.10492	-0.05731	-0.15	7
Huai nan	-0.30647	-0.48405	0.23959	-0.27	8
An qing	-0.32244	0.04291	-0.93124	-0.31	9
xuan cheng	-0.81352	0.98607	-1.033	-0.34	10
Lu an	-0.11889	-1.10788	0.0411	-0.37	11
Bo zhou	-0.01856	-1.28667	-0.07593	-0.38	12
Tong ling	-0.69606	0.58659	-0.99029	-0.38	13
Chi zhou	-0.81073	0.27146	-0.00595	-0.39	14
Su zhou	-0.06172	-1.15547	-0.23847	-0.4	15
Huang shan	-0.08615	-0.85359	-1.49046	-0.51	16

4. Result Analysis

4.1 Analysis of Higher Education Quality Evaluation Results

According to the result of factor analysis, the quality level of higher education in 16 cities of Anhui province has obvious difference and unbalance. Regional comprehensive strength factor F1 is the most influential factor, which plays a major role in promoting the regional higher education level of Anhui Province. Secondly, the proportion of teachers and students is F2. Therefore, the education quality level of Anhui Province should focus on improving the comprehensive strength of the region rather than only pursuing the development of a single direction.

In the final comprehensive ranking, it can be seen intuitively that Hefei, as the capital city of Anhui province, has a higher education quality level far higher than other cities. Hefei not only has many well-known universities in China, but also has much higher educational resources investment and human resources level than other cities, which leads to its highest level in the final evaluation of higher education quality level. Secondly, Wuhu, Huaibei, Maanshan and Chuzhou have high comprehensive scores, indicating that the level of higher education in these four regions is still in a rapid rise. The quality of higher education in the remaining 11 cities is in the middle and lower reaches of Anhui Province, which cannot reach the average level of education quality in Anhui Province. There is still a huge space for improvement in the future.

At the same time, it can be seen from the combination model of factor analysis that the comprehensive strength of regional education quality is an important force to promote the improvement of higher education in Anhui Province. Compared with the single investment of capital and teachers, only by focusing on improving the comprehensive strength of education in Anhui Province can the quality of higher education be comprehensively improved.

From the above analysis, it is also reflected from the side that the big difference of higher education quality level between different cities in Anhui Province and the uneven development between regions are the important reasons that hinder the improvement of the overall education quality level of Anhui Province.

4.2 Analysis of Results of Regional Economic Development Level

From the analysis results, it can be seen that economic structure and regional economic vitality F1 has the most significant impact on the economic development of various cities in Anhui Province, followed by economic quality F2, and social assets F3 has the least impact. It can be seen that the adjustment of industrial structure and the shaping of economic vitality play an indispensable role in the economic development of Anhui Province.

Similar to the analysis of higher education, Hefei, as the capital city of Anhui province, has a much higher level of economic development than other cities. The comprehensive score of Wuhu, Bengbu, Huaibei, Maanshan and chuzhou is positive, indicating that the higher education level of these four regions is still in the trend of rapid rise. The remaining 10 cities have a low level of regional economic development and cannot meet the needs of local development. At the same time, it can be seen from the

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combination model of factor analysis that it is important to promote the economic development of Anhui province to adjust the regional industrial structure, optimize the industrial layout and increase the economic vitality of Anhui Province.

4.3 Coupling Coordination Analysis Based On Higher Education and Economic Development Level

The comprehensive score of higher education and economic development level of each region obtained by factor analysis is used to determine the coordination degree of higher education and regional economy through the rank difference-D.

As can be seen from Table 12 below, there are 11 cities with D>0, namely huaibei, Fuyang, Huainan, Maanshan, Bengbu, xuancheng and Bozhou, indicating that the regional economic development is due to their higher education level. There are altogether four cities with D<0, namely Huangshan, Suzhou, Chuzhou, Tongling and Anqing. The higher education level of these cities is better than its regional economic development. The D=0 of Hefei, Wuhu, Liujia and Chizhou indicates that the regional economy matches the development of higher education.

As can be seen from the absolute value of rank difference D, there are 9 cities with D<3, including Hefei, Wuhu, Luan, Chizhou, Huaibei, Fuyang, Huainan, Maanshan, Huangshan and Bengbu, accounting for 50.6%, indicating that the coupling level of higher education and regional economic development in more than half of the cities in China is relatively coordinated. The coupling level of Hefei, Wuhu, Luan and Chizhou is relatively harmonious. However, it should be noted that the level of coupling coordination does not represent the level of regional higher education and economic development, or it may be caused by the low level of both. D=3 cities include Suzhou, Chuzhou, xuancheng, Tongling and Anqing, indicating that the coupling and coordination degree of these cities is basically out of balance. Only xuancheng&apos's higher education level is higher than its regional economic development. However, only one city with D=4 is Bozhou city, indicating that its higher education level does not match the regional economic development.

Table 12: Grade classification standard of coupling coordination degree between educations an economic

city	Higher education		Regional economy		Seating arrangement(D)	Coupling factor
	Synthesis score	sort	Synthesis score	sort		
He fei	3.08	1	2.10	1	0	coordinate
Wu hu	0.49	2	0.58	2	0	coordinate
Lu an	-0.30	11	-0.37	11	0	coordinate
Chi zhou	-0.47	14	-0.39	14	0	coordinate
Huai bei	-0.04	5	0.18	4	1	Relatively coordinate
Fu yang	-0.22	8	-0.15	7	1	Relatively coordinate
Huai nan	-0.26	9	-0.27	8	1	Relatively coordinate
Ma an shan	-0.02	4	0.53	3	1	Relatively coordinate
huangshan	-0.48	15	-0.51	16	-1	Relatively coordinate
Beng bu	-0.18	7	0.06	5	2	Relatively coordinate
Su zhou	-0.32	12	-0.40	15	-3	The basic coordinate
Chu zhou	-0.02	3	0.06	6	-3	The basic coordinate
Xuan cheng	-0.35	13	-0.34	10	3	The basic coordinate
Tong ling	-0.27	10	-0.38	13	-3	The basic coordinate
An qing	-0.15	6	-0.31	9	-3	The basic coordinate
Bo zhou	-0.49	16	-0.38	12	4	imbalance

5. Relevant Countermeasures and Suggestions

5.1 To Promote the Whole with the Local, Promote High-Quality Progress in Anhui Province

At present, Hefei, as the capital city of Anhui Province, ranks first in both higher education and regional economic development. Anhui province is making every effort to make Hefei one of the most important cities in China. Although this greatly promoted the development of Hefei, it also made the development of other cities in Anhui province tend to lag behind, and many surrounding cities completely fell behind the national average in both economic level and educational level. Therefore, the next step should be to promote the coordinated progress of other cities in Anhui province

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synchronously with the high quality development of Hefei.

5.2 Promoting High-Quality and Coupled Regional Economic Development

Except for a few cities in Anhui Province, most cities have low quality coupling development, that is, the level of higher education and regional economy is lower than the average level of Anhui Province. In this case, some cities should promote the progress of education level with local economic development, and give priority to the development of regional economy with only a few resources. At the same time, a few cities have low coupling degree between higher education and economic level, which is not conducive to their progress.

5.3 Formulate Policies In Light Of Local Conditions and Coordinate Regional Development

Policy making is an important force to promote regional development. Hefei&apos's progress is closely related to the support of the regional government. However, with the rise of the overall strength of Anhui Province, different regions in Anhui province need to improve the quality of higher education and regional economic development. Therefore, Anhui province and municipal governments should formulate corresponding policies according to the regional economic development and characteristics of higher education to promote regional economic development.

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