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Research on Evaluation of Liaoning's Economic Comprehensive Strength based on Factor Analysis and Cluster Analysis

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Abstract: This article takes Liaoning Province as the research object. According to its relevant data from 2013 to 2017, a total of 13 secondary indicators are selected from the four aspects of economic development level, residents' living standard, urban development potential, and finance and foreign trade. Using factor analysis method and cluster analysis method to evaluate the comprehensive economic strength of 14 prefecture-level cities in Liaoning Province. The results show that the comprehensive economic strength of Dalian and Shenyang is strong, while the comprehensive economic strength of Tieling and Fuxin is weak.

Keywords: Liaoning Province; Factor analysis; Cluster analysis; Comprehensive evaluation

1. Introduction

In recent years, the state of economic development has become a topic of concern. The state and the government have formulated a series of solutions in order to achieve macroeconomic goals such as full employment, stable price levels, rapid economic growth, and balance of payments, and to promote economic welfare. The guiding principles and measures for economic issues are also known as economic policies. On March 5, 2019, in a government work report, Premier Li Keqiang said that it is necessary to correctly grasp the macro policy orientation, continue to implement a proactive fiscal policy and a stable monetary policy, implement employment priority policies, strengthen policy coordination and cooperation, and ensure economic operation.

Promote sustainable and healthy economic and social development in a reasonable interval. With the continuous development of the economy and the implementation of various economic policies, the economic development of various regions has also received a certain degree of attention. The comprehensive economic strength is an important manifestation of the economic development of a city. It involves many important aspects. Economic indicators can not only measure the economic development level of a region, but also find out the positive effects of relevant economic policies and find problems in regional economic development.

Therefore, it is very meaningful to study the comprehensive economic strength of the region. Because of the regional differences between different provinces, this article selects Liaoning Province as the research object, and selects 13 secondary indicators from four aspects: economic development level, residents' living standard, urban development potential, and finance and foreign trade. According to its 2013 Relevant data from 2017, using factor analysis and cluster analysis to evaluate and evaluate the comprehensive economic strength of each prefecture-level city, and to make relevant suggestions for the improvement of regional economic comprehensive strength.

2. Literature Review

It is found through literature review that many scholars have carried out related research on the comprehensive economic strength of the region. For example, Wang Bei and Chang Jiancong [1] took the coastal areas as an example, selected 4 secondary indicators and 27 tertiary indicators to establish a regional marine economic competitiveness index system, and found that Shanghai, Shandong, and Guangdong's marine economic integrated The strongest strength and the largest contribution to the comprehensive strength of the marine economy is the strength of marine science and technology. Zou Hangbing and Wang Yichen [2] take Fujian Province as an example, perform a factor analysis on eight comprehensive indicators of each prefecture-level city, and find that to improve the comprehensive economic strength, it is necessary to improve the level of objective economic factors and the level of economic development. Han Liu [3] took Xinjiang Province as the research object, selected representative economic indicators such as per capita GDP and total fixed investment, and used the improved model of the factor entropy method to evaluate the comprehensive economic strength of various regions in Xinjiang Province. Research and make relevant recommendations. Chen Jiabin [4] selected 3 secondary indicators and 14 tertiary indicators to establish a comprehensive

evaluation index system, and used the entropy weight-TOPSIS model to conduct an empirical analysis of the comprehensive economic development strength of 84 districts and counties in Fujian Province based on the relevant data in 2018 Through general analysis and spatial comparison, it is found that the regional economic development in different regions of Fujian Province is very different, and the imbalance trend in development level and spatial distribution is very obvious. Lin Xiaoxiao [5] used principal component analysis to compare and evaluate the comprehensive economic strength of the five major cities in the Northwest, and found that the uneven economic development in the Northwest was more prominent.

3. Empirical Analysis

3.1. Establishment of evaluation index system

The comprehensive economic strength is affected by many aspects, so it is very important to choose representative economic indicators. According to the relevant economic indicators involved in the existing research and follow the completeness, availability and validity of the data, this article selects from four aspects: economic development level, residents' living standard, urban development potential, and finance and foreign trade. 13 relevant indicators were established, and an evaluation index system was established to evaluate and rank the comprehensive economic strength of each city in Liaoning Province. see Table 1.

Table 1. Evaluation index system of comprehensive economic strength of prefecture-level cities in Liaoning Province

Solution layer	Indicator layer	Variable
The level of economic development	GDP	X1
	GDP per capita	X2
	Total fixed asset investment	X3
Living standard of residents	Per capita disposable income of urban residents	X4
	Per capita annual consumption expenditure of residents	X5
	Number of employees	X6
Urban development potential	Total population at the end of the year	X7
	Post and telecommunication traffic	X8
	Number of health institutions	X9
Finance and Foreign Trade	Fiscal General Public Budget Revenue	X10
	Total imports	X11
	Total exports	X12
	Deposit balances of financial institutions	X13

3.2. Data source and processing

The research object of this article is 14 prefecture-level cities in Liaoning Province, and the relevant data comes from the Liaoning Statistical Yearbook. Due to the differences in dimensions and orders of magnitude between different economic variables, if the original data shown in the statistical yearbook is used directly, certain deviations may occur in the process of factor analysis. In order to ensure the effectiveness of empirical analysis, first The original data should be standardized to eliminate errors caused by different dimensions, self-variation, or large values. Use the following formula:

$$X_i^* = (X_i - u_i) / \sqrt{s_i}$$

Among them, Xi is the original data displayed in the statistical yearbook of Liaoning Province, ui is the sample mean, σi is the sample variance, and Xi* is the relevant data after normalization.

3.3. Factor analysis

The factor analysis method is often used in comprehensive evaluation. It can convert multiple original complex economic indicators into fewer, representative comprehensive factors starting from the correlations within the selected economic indicators. This provides convenience for subsequent quantitative calculation and research.

3.3.1. Suitability test

Before performing the factor analysis, we first need to test the adaptiveness of the research objects, namely the KMO and Bartlett spherical tests. Enter the standardized data into the software. If the output shows that the KMO test value is greater than 0.5, it means that there is a certain correlation between these data and factor analysis can be performed. The significance level of the Bartlett test is 0.05. This article uses SPSS25.0 software to perform factor analysis on the relevant data of Liaoning's economic comprehensive strength and economic indicator system from 2013 to 2017. The results are shown in Table 2.

Table 2. KMO test and Bartlett spherical test

Years	KMO inspection	Bartlett test		
		Approximate chi-square	df	Sig.
2013	0.566	446.506	78	0

2014	0.618	436.905	78	0
2015	0.612	413.540	78	0
2016	0.531	447.583	78	0
2017	0.562	424.457	78	0

According to the results in Table 2, the KMO inspection value in 2013 was 0.566, the KMO inspection value in 2014 was 0.618, the KMO inspection value in 2015 was 0.612, the KMO inspection value in 2016 was 0.531, and the KMO inspection value in 2017 It is 0.562. The statistical value of the KMO test is greater than 0.5 in each year, and the significance level of the Bartlett spheric test is 0, which are far less than the critical value of 0.05. This indicates that the data has a certain correlation and can be studied by factor analysis.

3.3.2. Extract factor variables

Based on the above analysis, use SPSS25.0 software to perform principal component analysis on the relevant data of each year to obtain the eigenvalues and variance contribution rates of the common factors. The default condition for selecting the common factors is that the initial eigenvalue is greater than 1, the specific results See Table 3.

Table 3. Eigenvalue and variance contribution rate of factor analysis

Years	Ingredient	Initial eigenvalue			Extract load sum of squares			Sum of squared rotation loads		
Project	Project	total	Variance percentage	Cumulative%	total	Variance percentage	Cumulative%	total	Variance percentage	Cumulative%
2013	1	10.111	77.773	77.773	10.111	77.773	77.773	6.337	48.743	48.743
	2	1.657	12.744	90.517	1.657	12.744	90.517	5.431	41.774	90.517
2014	1	10.379	79.840	79.840	10.379	79.840	79.840	6.200	47.689	47.689
	2	1.662	12.786	92.626	1.662	12.786	92.626	5.842	44.937	92.626
2015	1	10.375	79.807	79.807	10.375	79.807	79.807	6.194	47.648	47.648
	2	1.628	12.519	92.326	1.628	12.519	92.326	5.808	44.678	92.326
2016	1	10.491	80.697	80.697	10.491	80.697	80.697	6.986	53.741	53.741
	2	1.389	10.684	91.381	1.389	10.684	91.381	4.893	37.640	91.381
2017	1	10.427	80.208	80.208	10.427	80.208	80.208	6.862	52.786	52.786
	2	1.416	10.889	91.097	1.416	10.889	91.067	4.981	38.312	91.097

According to the principle of factor extraction, two common factors are extracted each year. The cumulative variance contribution rate of each year from 2013 to 2017 exceeded 90%, indicating that the extraction effect is very good, and the data loss is small. The two common factors in each year can better represent the 13 selected secondary indicators. , So as to achieve the purpose of factor analysis and dimensionality reduction. At the same time, it can also be seen from the lithotripsy that the slope of the first two factors is large, and the eigenvalue is greater than 1, which has a good degree of explanation for the total variance. The next step is to study and explore.

3.3.3. Factor rotation

After extracting the principal components, a load matrix is established. Because the common factors of the initial matrix have relatively close loads on each data index, analysis of the common factor classification is difficult, so the maximum variance method is used to maximize the orthogonal rotation of the factors. Based on this, a factor loading matrix is established to make the common factor more representative and economically meaningful. Because the analysis process is the same for each year, only the relevant data of 2017 is taken as an example here.

Table 4. Component matrix after rotation

Evaluation index	Ingredient	
	1	2
GDP	0.753	0.651
GDP per capita	0.963	0.142
Total fixed asset investment	0.796	0.591
Per capita disposable income of urban residents	0.911	0.221
Per capita annual consumption expenditure of residents	0.883	0.245
Number of employees	0.714	0.669
Total population at the end of the year	0.394	0.913
Post and telecommunication traffic	0.608	0.769
Number of health institutions	0.021	0.962
Fiscal General Public Budget Revenue	0.737	0.669
Total imports	0.744	0.424

Total exports	0.731	0.371
Deposit balances of financial institutions	0.678	0.719

According to the results in Table 4, it can be seen that the first common factor in regional GDP, per capita GDP, total investment in fixed assets, per capita disposable income of urban residents, average annual consumption expenditure per capita, number of employees, There is a large load on the general public budget revenue, total imports, and total exports. The first common factor is named the total economic strength factor. The second common factor is the total population, post and telecommunications volume, and number of health institutions at the end of the year 2. There is a large load on the deposit balance of financial institutions. The second common factor is named the factor of comprehensive economic strength.

3.3.4. Calculate the factor score

Using regression method to estimate the factor score coefficient, we can get the factor score coefficient matrix, as shown in Table 5, and then use the EXCEL tool to calculate the comprehensive factor score according to the relevant data and linear relationship in the table.

Table 5. Factor score coefficient matrix

Evaluation index	ingredient	
Project	1	2
GDP	0.060	0.078
GDP per capita	0.283	-0.221
Total fixed asset investment	0.092	0.037
Per capita disposable income of urban residents	0.241	-0.169
Per capita annual consumption expenditure of residents	0.225	-0.150
Number of employees	0.041	0.098
Total population at the end of the year	-0.139	0.307
Post and telecommunication traffic	-0.024	0.176
Number of health institutions	-0.280	0.441
Fiscal General Public Budget Revenue	0.049	0.091
Total imports	0.125	-0.025
Total exports	0.136	-0.046
Deposit balances of financial institutions	0.014	0.132

Combine the factor scoring coefficients in Table 5 and use the linear combination of the 13 selected economic indicator variables to represent the two extracted common factors, thereby obtaining the scoring function for each factor:

$$F1 = 0.060X1 + 0.283X2 + 0.092X3 + 0.241X4 + 0.225X5 + 0.041X6 - 0.139X7 - 0.024X8 - 0.280X9 + 0.049X10 + 0.125X11 + 0.136X12 + 0.014X13$$

$$F2 = 0.078X1 - 0.221X2 + 0.037X3 - 0.169X4 - 0.150X5 + 0.098X6 + 0.307X7 + 0.176X8 + 0.441X9 + 0.091X10 - 0.025X11 - 0.046X12 + 0.132X13$$

If only the score of a factor is used to represent the comprehensive economic strength of a region, there are bound to be certain limitations, and it is impossible to give a complete overview of the economic development of the region. Therefore, a weighted calculation is performed according to the variance contribution rate of two common factors. Calculate the factor comprehensive score $Y = (52.786F1 + 38.312F2)/91.097$ for each prefecture-level city by weighting the variance contribution rate. Table 6 shows the scores and corresponding rankings of prefecture-level cities for each year.

Table 6 (a). Scores and rankings of local cities by year

Time	Project	Shenyang	Dalian	Anshan	Fushun	Benxi	Dandong	Jinzhou
2013	Score	1.45	1.82	0.11	-0.32	-0.35	-0.34	-0.20
	Ranking	2	1	3	8	11	10	6
2014	Score	1.42	1.83	0.07	-0.27	-0.26	-0.34	-0.21
	Ranking	2	1	3	8	7	10	6
2015	Score	1.53	1.74	0.07	-0.30	-0.29	-0.34	-0.18
	Ranking	2	1	3	8	7	10	6
2016	Score	1.46	1.81	0.03	-0.27	-0.24	-0.34	-0.20
	Ranking	2	1	3	8	7	10	6
2017	Score	1.48	1.79	0.01	-0.26	-0.25	-0.35	-0.21

	Ranking	2	1	4	8	7	10	6

Table 6 (b). Scores and rankings of local cities by year

Time	Project	Yingkou	Fuxin	Liaoyang	Panjin	Tieling	Chaoyang	Huludao
2013	Score	-0.14	-0.51	-0.37	-0.19	-0.36	-0.27	-0.33
	Ranking	4	14	13	5	12	7	9
2014	Score	-0.11	-0.49	-0.36	-0.16	-0.43	-0.32	-0.38
	Ranking	4	14	11	5	13	9	12
2015	Score	-0.08	-0.51	-0.35	-0.17	-0.41	-0.32	-0.37
	Ranking	4	14	11	5	13	9	12
2016	Score	-0.06	-0.53	-0.32	0.02	-0.52	-0.41	-0.42
	Ranking	5	14	9	4	13	11	12
2017	Score	-0.07	-0.54	-0.30	0.02	-0.52	-0.40	-0.39
	Ranking	5	14	9	3	13	12	11

From the results in Table 6, it can be seen that from 2013 to 2017, the comprehensive scores of the three prefecture-level cities in Shenyang, Dalian, and Anshan were all positive, of which Dalian has been ranked first and Shenyang has been ranked It is ranked second, and the factors of the comprehensive scores of the two prefecture-level cities in each year are similar, and the fluctuation range is small. This shows that these two cities have obvious leading advantages in Liaoning Province, and their development status is very stable. Anshan has been ranked third from 2013 to 2016, but it has retreated to fourth place in 2017. From the comprehensive score of factors, the overall score of Anshan has also shown a downward trend, indicating that the overall economic strength of Anshan City is nearly It has declined slightly over the years. Except for these three cities, the factor comprehensive scores of other prefecture-level cities in each year are mostly negative. It can be seen that the comprehensive economic strength of the cities of Dalian and Shenyang in Liaoning Province is very strong, but the economic comprehensive strength of most other prefecture-level cities is below average, indicating that Dalian and Shenyang are promoting the overall economic strength of the province. It's not enough to improve. Panjin has changed a lot in recent years. From 2013 to 2017, the comprehensive score of the factor has been steadily advancing, especially in 2016, the comprehensive score suddenly changed from negative to positive, and the value increased is large, and the overall economic strength has improved. Quickly, the ranking came to third place. The four cities of Fushun, Dandong, Jinzhou, and Fuxin are very stable, and their overall economic strength has been in the same ranking in the province for five consecutive years. The rankings of Yingkou, Liaoyang, Panjin, Tieling, Chaoyang and Huludao have changed slightly, but it is not obvious. From 2014, Tieling and Fuxin's comprehensive economic strength has been in the bottom two of the province, indicating that their development is relatively backward. On the whole, regardless of the change in rankings or the comparison of scores in each year, the overall economic strength of the prefecture-level cities in Liaoning Province is relatively stable, and will not significantly degrade or significantly improve. It also shows that the comprehensive economic strength of a region involves There are many factors that do not change significantly in the short term.

In addition to the factor comprehensive score and ranking, from the point of view of the largest difference in the factor comprehensive score in each year, from 2013 to 2017, the largest factor comprehensive score showed a trend of first decrease and then increase, and the largest difference in 2015 Reached a minimum, then gradually increased. However, the overall change of the maximum difference is very small, and the value of each year is basically around 2.3, which further illustrates that the overall economic strength of the province is relatively stable and the change is small.

3.4. Cluster analysis

Based on the factor analysis, the cluster analysis method was used to divide the comprehensive economic strength of the prefecture-level cities in Liaoning Province into four categories: excellent, good, average, and backward. The results are shown in Table 7.

Table 7. Cluster analysis results by city and year

Comprehensive economic strength	Year 2013	Year 2014	Year 2015	Year 2016	Year 2017
Excellent	Dalian, Shenyang	Dalian, Shenyang	Dalian, Shenyang	Dalian, Shenyang	Dalian, Shenyang
Good	Anshan, Yingkou, Panjin	Anshan, Yingkou, Panjin	Anshan, Yingkou, Panjin	Anshan, Panjin, Yingkou	Panjin, Anshan, Yingkou
General	Jinzhou, Chaoyang, Fushun, Huludao, Dandong, Benxi,	Jinzhou, Benxi, Fushun, Chaoyang, Dandong, Liaoyang, Huludao	Jinzhou, Benxi, Fushun, Chaoyang, Dandong, Liaoyang, Huludao	Jinzhou, Benxi, Fushun, Liaoyang, Dandong, Chaoyang,	Jinzhou, Benxi, Fushun, Liaoyang, Dandong, Huludao, Chaoyang

	Tieling			Huludao	
Behind	Liaoyang, Fuxin	Tieling, Fuxin	Tieling, Fuxin	Tieling, Fuxin	Tieling, Fuxin

The first category is areas with excellent overall economic strength. In this category have been Dalian and Shenyang. As the capital of Liaoning Province, Shenyang is located in the center of the province, and its geographical location is very important. At the same time, it is a traditional industrial base and a national historical and cultural city. Both economic and cultural development are at the forefront of the province, so the comprehensive economic strength is naturally strong. Dalian is a very famous port city. It is located on the edge of Liaoning Province. Its geographical location provides good conditions for its foreign trade. Therefore, its level of foreign trade development is very high. At the same time, Dalian has a very beautiful scenery. Many tourists come here to visit, which can promote economic development. Whether it is foreign trade or tourism, it has a positive effect on the stability and improvement of the overall economic strength.

The second category is areas with good overall economic strength. The three cities in this category are Anshan, Yingkou and Panjin. The order of the first four years is the same, but in 2017 Panjin came to the first place in the good rank. It may be because Panjin is an important petroleum and petrochemical industrial base in China, and industrial development is the cornerstone of the improvement of the comprehensive economic strength.

The third category is general economic strength. According to the needs of analysis, seven cities are classified into this level. Tieling was still in this general level in 2013, but it has entered the backward level since 2014 and replaced by Liaoyang. Liaoyang is the only city in the fourteen prefecture-level cities that has improved in level. It can also clearly see its progress in the previous factor comprehensive score, not only from the backward level to the general level, but also from 2016 onwards. In fourth place in the general rank.

The fourth category is the areas with backward comprehensive economic strength. Since 2014, Tieling and Fuxin have been at this level. According to the results of the factor analysis method, the two cities do have a large gap in factor comprehensive scores compared to other cities, and the gap between the two cities is narrowing.

4. Related Suggestions

This paper uses factor analysis and cluster analysis to evaluate the comprehensive economic strength of cities in Liaoning Province. It is found that the economic development of different cities is not balanced, and the overall economic strength of the province is relatively stable without major changes. In order to better enhance the comprehensive economic strength of prefecture-level cities in Liaoning Province, the following suggestions are made:

First, implement various policies issued by the state and government in a timely manner, seize opportunities at all times, and focus on the economic development and improvement of the province.

Second, different regions should strengthen cooperation beforehand to improve the overall economic strength of less developed regions. Liaoning is a traditional industrial province, which is relatively developed as a whole, but there is a lot of room for improvement in economic development in many regions. Regional cooperation should be further strengthened to promote economic cooperation and development in various cities and jointly build an industrial supporting system. Actively introduce high-quality enterprises and capital and human resources.

Third, give play to the advantages of "excellent" regions and promote the coordinated development of each region. As excellent cities, Shenyang and Dalian are also sub-provincial cities in Liaoning Province. Their comprehensive economic strength has a very obvious leading advantage over other cities. Therefore, it should play a leading role in the economic development of surrounding cities, so that many cities with lower comprehensive scores can develop together and make progress together.

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