Frontiers in Business, Economics and Management
ISSN: 2766-824X | Vol. 21, No. 2, 2025

Analysis of the Comprehensive Economic Strength of Cities in Sichuan Province Based on Principal Component Analysis

Yier Wang

Southwest Petroleum University, Chengdu, China
944268152@qq.com

Abstract: This paper evaluates the comprehensive economic strength of 18 cities in Sichuan Province based on principal component analysis. By selecting 10 economic indicators such as gross regional product, total investment in fixed assets, financial general budget revenue, total merchandise export, gross product of each industry, gross product per capital, disposable income of urban residents and resident population, principal component analysis is carried out by using SPSS software. The results show that Chengdu City is clearly ahead of other cities in terms of comprehensive economic strength, with its economic total, structure and efficiency outstanding, showing a very strong economic agglomeration and radiation capacity. Yibin City and Mianyang City also show strong comprehensive economic strength. The findings of this paper provide a scientific basis for the formulation of economic development policies for the cities in Sichuan Province, aiming to promote the coordinated and high-quality development of the regional economy.

Keywords: Principal component analysis; Sichuan Province cities; Comprehensive economic strength.

1. Introduction

Since the reform and opening up, China's development has been rapid, rapid growth of the national economy, by 2010 to leap to the world's second largest economy, 2020 by the impact of the epidemic, but the GDP does not decrease but rather increase. With the rapid growth of China's economy, there is an imbalance in economic development as well as uncoordinated regional development and other issues. The Pearl River Delta, Yangtze River Delta and the Bohai Economic Rim economic performance is strong, the central region economic performance is slightly inferior, while the western region, the northeastern region of the economic performance of the difference is very far, the regional economic development is extremely unbalanced. In order to solve the problem of unbalanced economic development in China, China has implemented a number of strategies to promote the coordinated development of regional economy, and before formulating strategies and introducing relevant policies, we should first assess the comprehensive economic strength of each region. We should understand the strengths and weaknesses of each region's economic development, identify the root causes of the problems, and target solutions to the problem of unbalanced development [1].

Increasing market competition and closer interregional cooperation have made regional economic integration more pronounced. Against this background, the study of regional economy and comprehensive economic strength will help to better formulate relevant policies to promote regional economic development, thus better promoting regional economic development. In order to make Sichuan Province more coordinated and high-quality development. This paper mainly studies 10 economic indicators of 18 urban areas in Sichuan Province in 2022, and assesses the economic level of each city through principal component analysis of the economic indicators of the cities, so as to provide strong support for the development of Sichuan Province.

2. Literature Review

The research on the construction of the indicator system for the evaluation of comprehensive economic strength can be traced back to the 1980s, and the first research was on international competitiveness, which was further developed into assessing the competitiveness of cities and constructing the evaluation indicator system. Miao Runsheng (2004) constructed China's evaluation index system from the two aspects of economic development status and economic development potential [2]. Yang Shanli (2014) selected eight indicators in all directions and multiple angles to evaluate the comprehensive economic strength of 11 coastal provinces and cities [3]. Lin Xiaoxia (2019) studied the comprehensive economic strength of Northwest China from the aspects of economic strength, scientific and educational strength, living standard of residents, infrastructure construction, and outer box economic strength [4]. Li Qi (2021) evaluated the comprehensive economic strength of cities in Shanxi Province from three aspects: comprehensive economic strength, economic structure and economic efficiency [5]. Pan Yurong (2022) and others constructed an evaluation index system to evaluate the comprehensive economic strength of each index system in Zhejiang Province [6]. Constructing the indicator system is a key step in the evaluation of comprehensive economic strength, and this paper carries out innovation and integration on the basis of the predecessors in the construction of indicators. The cities and provinces of Sichuan Province as a case that has not been studied by previous researchers, this paper carries out the evaluation of the comprehensive economic strength of the cities in Sichuan Province on the principal component analysis method, so as to provide an important basis for the development of Sichuan Province.

3. Introduction to the Methodology and Description of the Data

3.1. Principal Component Analysis

Principal component analysis is a statistical method that converts a larger set of correlated variables into a small number of highly uncorrelated variables by orthogonal transformation and retains as much of the original information as possible; these derived uncorrelated variables are called principal components. For example, the first principal component is shown below, where xi is the original variable and ai is the coefficient obtained from the transformation.

$$F_1 = a_1x_1 + a_2x_2 + a_3x_3 + \cdots + a_px_p$$

3.2. Data Description

The data of the constituency of this paper are from the 2022 statistical yearbook of Sichuan Province. In order to construct a reasonable index system, this paper considers the principles of scientificity, comprehensiveness and operability, and constructs the following 10 basic variables by dividing the composition of a city's economic strength into economic aggregate, economic structure, economic benefit and other elements: X1 is the gross domestic product of the region, X2 is the total investment in fixed assets (for the selected property investment in this paper), X3 is the regional general budget revenue, X4 is the total merchandise exports of the region, X5 is the total regional production of the primary industry, X6 is the total regional production of the secondary industry, X7 is the total regional production of the tertiary industry, X8 is the per capital gross domestic product of the region, X9 is the disposable income of the urban residents of the region, and X10 is the permanent resident population of the region. Since the sum of the three industries' gross product is equal to the gross product, the following section will take advantage of the nine basic variables after the principal component analysis.

4. Empirical Analyses

4.1. Feasibility Testing

Prior to principal component analysis, the feasibility of the data was analysed using the KMO test, as can be seen in Table 1, the KMO value is 0.841 greater than 0.8, while the P value is close to 0. According to the test criteria of KMO indicates that the commonality between the variables is stronger and the results are significant, making it suitable for principal component analysis [7].

Table 1. KMO and Bartlett's test

KMO Quantity of Sample Suitability		0.841
Bartlett sphericity test	approximate chi-square (math.)	376.122
	(number of) degrees of freedom (physics)	36
	significance	0.000

4.2. Standardization and Correlation Coefficient Matrix

This paper adopts the sample data of 9 variables from 18 cities in Sichuan Province. Firstly, the above sample data are standardised to eliminate the influence of different scales between indicators. Then the correlation coefficient matrix between the variables was obtained through SPSS as shown in Table 2, from which it can be seen that the correlation coefficients between the variables are larger, indicating that the correlation between the variables is stronger, and the effect of the subsequent principal component analysis will be more significant.

Table 2. Matrix of correlation coefficients of economic indicators

norm	X2	X3	X4	X5	X6	X7	X8	X9	X10
X2	1.000	.995	.990	.675	.970	.993	.480	.776	.977
X3	.995	1.000	.997	.652	.973	.997	.499	.785	.976
X4	.990	.997	1.000	.613	.960	.996	.491	.785	.969
X5	.675	.652	.613	1.000	.730	.672	.219	.336	.742
X6	.970	.973	.960	.730	1.000	.974	.595	.810	.970
X7	.993	.997	.996	.672	.974	1.000	.499	.781	.980
X8	.480	.499	.491	.219	.595	.499	1.000	.844	.472
X9	.776	.785	.785	.336	.810	.781	.844	1.000	.724
X10	.977	.976	.969	.742	.970	.980	.472	.724	1.000

4.3. Determination of Principal Factors

The 9 eigenvalues of the matrix can be obtained by SPSS, according to the principle of eigenvalue greater than 1, as shown in Fig. 1 gravel diagram, there are two eigenvalues greater than 1, and the other 7 eigenvalues are less than 1, so we get 2 factors extracted from the first 9 variables. From the total variance interpretation in Table 3, the cumulative variance contribution rate of the first two factors reaches 93.792%, indicating that the first two principal components already contain most of the information among the 9 variables, and the analysis results are reliable.

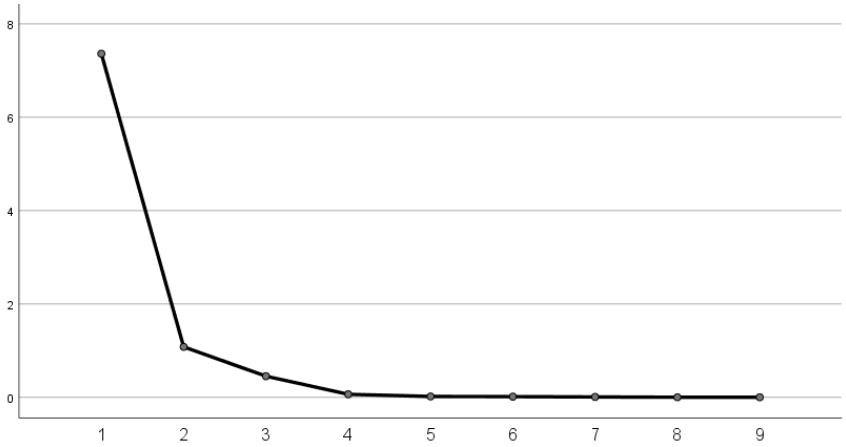

Figure 1. Gravel diagram

Table 3. Total Variance Explained

ingredient	Initial eigenvalue			Extract the sum of the squares of the loads			Rotational load sum of squares		
	total	Percentage of variance	Cumulative %	total	Percentage of variance	Cumulative %	total	Percentage of variance	Cumulative %
1	7.361	81.789	81.789	7.361	81.789	81.789	5.677	63.082	63.082
2	1.080	12.003	93.792	1.080	12.003	93.792	2.764	30.710	93.792
3	.452	5.024	98.816						
4	.064	.716	99.533						
5	.018	.203	99.736						
6	.014	.153	99.889						
7	.008	.088	99.977						
8	.001	.017	99.994						
9	.001	.006	100.000						

4.4. Interpretation of Principal Components

Table 4. Component matrix after rotation

	ingredient	
	1	2
X2	.897	.418
X3	.884	.442
X4	.871	.450
X5	.848	-.054
X6	.864	.488
X7	.892	.433
X8	.141	.936
X9	.454	.868
X10	.920	.365

In order to better interpret the sample data, the factors are rotated to get the component matrix shown in Table 4, the first principal component contains a lot of information, the variance contribution rate reaches 63.082%, including X2 total investment in fixed assets, X3 general budget revenue of the regional treasury, X4 total exports of goods in the region, X5 total production of the primary industry in the region, X6 total production of the secondary industry in the region, X7 total production of the tertiary industry in the region, X10 is the size of the resident population in the region, these indicators reflect the economic information of urban development. The second principal component has a variance contribution rate of 30.712%, including X8 as regional gross domestic product per capital and X9 as regional disposable income of urban residents, which obviously reflect the information related to urban residents, and is factor 1 (F1). 2 (F2).

4.5. Empirical Findings

Finally, the principal component score coefficients were calculated using SPSS, as shown in Table 5:

First principal component:

$$F1=0.166X2+0.153X3+0.145X4+0.314X5-0.129X6+0.159X7-0.278X8-0.146X9+0.192X10$$

Second principal component:

$$F2 = -0.015X2 + 0.006X3 + 0.017X4 - 0.335X5 + 0.046X6-0.003x7+0.619x8+0.461x9- 0.061x10$$

Combined score: $F = (63.082F1 + 30.712F2) / 93.792$

Table 5. Matrix of component score coefficients

	ingredient	
	1	2
X2	.166	-.015
X3	.153	.006
X4	.145	.017
X5	.314	-.335
X6	.129	.046
X7	.159	-.003
X8	-.278	.619
X9	-.146	.461
X10	.192	-.061

Applying the above conclusions, the comprehensive economic strength of 18 cities in Sichuan Province is evaluated as shown in Table 6. From the F1 factor scores, it can be seen that Chengdu, Nanchong and Dazhou are ranked in the top three; from the F2 factor scores, it can be seen that Panzhihua, Chengdu and Dazhou are ranked in the top three; and from the F total factor scores, it can be seen that Chengdu, Yibin and Mianyang have higher scores and are ranked in the top three; as the capital city of Sichuan Province, Chengdu is regarded as the strongest comprehensive economic strength among the 18 cities. As the capital city of Sichuan Province, Chengdu City has the strongest comprehensive economic strength among the 18 cities. Chengdu City is regarded as a pole core city with reasonable flow of factors and efficient agglomeration in the western region, and ranks among the mega-cities, with the total economic volume crossing eight consecutive steps of 100 billion yuan, and in recent years, the economy has been developing rapidly in all aspects, which will be comprehensively built into a nationally important centre of economy, science and technology, finance, culture and creativity, external communication and an international comprehensive transport and communication hub. The second and third ranked cities scored a huge difference with Chengdu, Chengdu scored 2.917661, while Yibin scored 0.137907, Mianyang scored 0.128526, and Nanchong scored 0.069068.

Table 6. Comprehensive Economic Strength Score of 18 Municipalities in Sichuan Province

municipalities	F1	rankings	F2	rankings	Total F	rankings
Chengdu	3.48112	1	1.760134	2	2.917661	1
Zigong	-0.47545	16	0.217877	6	-0.24843	11
Panzhihua	-1.66351	18	2.556157	1	-0.28182	14
Luzhou	-0.15136	9	0.146222	8	-0.05392	7
Deyang	-0.42227	15	0.713057	3	-0.05052	6
Mianyang	0.050078	5	0.289651	5	0.128526	3
Guangyuan	-0.24878	11	-0.62143	15	-0.37081	16
Suining	-0.31323	13	-0.17108	11	-0.26669	12
Neijiang	-0.13749	8	-0.34362	12	-0.20499	10
Leshan	-0.359	14	0.390761	4	-0.1135	8
Nanchong	0.802552	2	-1.4375	18	0.069068	4
Meishan	-0.19364	10	-0.10474	10	-0.16453	9
Yibin	0.101974	4	0.211704	7	0.137907	2
Guang'an	-0.11043	7	-0.60183	13	-0.27134	13
Dazhou	0.545459	3	-1.26719	17	-0.04808	5
Ya'an	-0.55705	17	0.11672	9	-0.33644	15
Bazhong	-0.04015	6	-1.25155	16	-0.43682	18
Ziyang	-0.30885	12	-0.60334	14	-0.40528	17

5. Conclusion

Based on the data search and empirical analyses in this paper, the comprehensive economic strength scores of cities in Sichuan Province show obvious regional differences. Chengdu City tops the list in several principal component scores, showing its strong momentum in economic development, especially in terms of economic aggregate, economic structure and economic efficiency. Yibin City and Mianyang City also demonstrate strong overall economic strength, although there is still a gap compared to Chengdu City. Nanchong City has higher scores in certain economic indicators, but is slightly behind in overall comprehensive strength. The main factors affecting the comprehensive economic strength of each city include total investment in fixed assets, general budget revenue, total merchandise exports, gross domestic product (GDP) of the primary industry, gross domestic product (GDP) of the secondary industry, gross domestic product (GDP) of the tertiary industry, gross domestic product (GDP) per capital and disposable income of urban residents. Together, these indicators constitute the main evaluation dimension of the comprehensive economic strength of each city. As the capital city of Sichuan Province, Chengdu has a strong economic agglomeration and radiation capability, driving the development of the neighbouring regions. However, other cities also show their own characteristics and advantages in economic development, forming a diversified development pattern. In the future, Sichuan Province should continue to play the core driving role of Chengdu City, while focusing on improving the economic development level of other cities, and promoting the balanced development of the province's economy. The analyses in this paper provide a scientific basis for the formulation of regional economic policies, and help to further promote the coordinated development of the regional economy and the enhancement of the overall economic strength of Sichuan Province.

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Appendix

city	X1	X2 (billion)	X3 (million)	X4 (million)	X5	X6	X7	X8	X9	X10
Chengdu	20817.5	3267.9	15206949.0	12527409.0	588.42	6404.12	13824.96	98149.0	54897.0	2126.8
Zigong	1638.4	119.5	454836.0	78331.0	253.31	621.32	763.79	66602.0	43740.0	245.2
Panzhihua	1220.5	110.6	439514.0	79217.0	112.22	677.79	430.51	100454.0	50009.0	121.6
Luzhou	2601.5	291.0	1171933.0	283520.0	277.17	1330.67	993.68	61054.0	45071.0	426.3
Deyang	2816.9	214.1	1203787.0	273401.0	296.22	1354.92	1165.73	81412.0	44650.0	346.1
Mianyang	3626.9	434.2	1317035.0	405008.0	381.47	1514.33	1731.14	74171.0	45131.0	489.8
Guangyuan	1139.8	126.7	399702.0	21708.0	214.02	445.44	480.32	50056.0	40687.0	227.1
Suining	1614.5	199.2	828347.0	118551.0	220.99	772.88	620.6	58137.0	42217.0	277.2
Neijiang	1657.0	184.7	514896.0	59161.0	293.18	544.88	818.89	53485.0	43639.0	308.8
Leshan	2308.8	143.6	1119753.0	167507.0	300.96	992.21	1015.64	73226.0	44376.0	315.3
Nanchong	2685.5	349.3	868472.0	90492.0	502.05	1012.98	1170.42	48343.0	41126.0	554.9
Meishan	1635.5	485.2	1299022.0	177319.0	242.31	657.61	735.59	55273.0	43949.0	303.7
Yibin	3427.8	367.2	1560765.0	473983.0	395.96	1723.21	1308.67	74341.0	44739.0	499.1
Guang'an	1425.0	193.4	716230.0	57196.0	247.18	444.2	733.64	43901.0	43078.0	272.9
Dazhou	2502.7	268.8	1180272.0	108869.0	432.99	913.78	1155.95	46588.0	41210.0	351.1
Ya'an	902.5	72.7	492778.0	80579.0	169.45	283.66	449.4	62981.0	42404.0	431.0
Bazhong	765.0	69.5	366083.0	13586.0	192.08	196.85	376.08	28641.0	40783.0	226.6
Ziyang	948.2	114.1	384174.0	58778.0	194.17	290.44	463.55	41586.0	42419.0	128.4