Comprehensive evaluation of Shenzhen's economic development level based on the improved Grey Relational Analysis

Lei Zhang

School of Economics and Management, Nanchang Hangkong University, Nanchang 330063, China

1430266702@qq.com

Abstract

Under the development background of the 40th anniversary of reform and opening-up, the economic development level of Shenzhen is taken as the research object, and the Analytic Hierarchy Process (AHP) and Grey Relational Analysis (GRA) are introduced to study the economic development of Shenzhen. Firstly, this paper builds a four-dimensional evaluation index system including economic aggregate, economic speed, economic quality and economic efficiency; then, the weight of each index is calculated by using the AHP; finally according to the statistical data of each index from 2006 to 2016 in Shenzhen, combined with the improved GRA, the grey relational coefficient of the indicators is obtained. The results show that: from 2006 to 2015, Shenzhen's economic development remains stable growth, the highest grey relational coefficient of 2015 is 0.771, and the minimum of 2006 is 0.406. The research provides reference value for the further improvement of Shenzhen's economy.

Keywords

AHP; Grey Correlation Analysis; Shenzhen; Economic Development.

1. Introduction

The 19th CPC national congress report pointed out that China's economy has shifted from a stage of high-speed growth to a stage of high-quality development. We must adhere to the principle of "quality first, efficiency first, speed up the building of a manufacturing power, and promote China's industries to move toward the medium-high end of the global value chain." As a beautiful epitome of the new generation's economic progress, shenzhen has grown from a border town to a modern, internationalized megalopolis with a population of more than 10 million after 40 years of reform and development[1-3]. In 1979, the regional GDP was only 197 million yuan, with a per capita GDP of 606 yuan, to 2017, the GDP reached 2.24 trillion yuan, with a per capita GDP of 1831 thousand yuan (about 271 thousand us dollars), and the GDP growth rate reached 23%. In 1979, the port of shenzhen shekou crashing rang reclamation built first run, let now become the most important domestic high-tech enterprises in shenzhen hub and innovation base, and the third world financial center cities, from the beginning of reform and opening up the floor "three days" shenzhen speed, to every year two or three thousands of new startups oasis "innovation", in the 40 years of surging ahead, great changes have taken place in shenzhen. Behind shenzhen's speed and miracle lie China's 40 years of reform and opening-up.

At present, domestic scholars have previously done a lot of research on the development of Shenzhen's economy. Deng [4] discussed Shenzhen as the core hub for the development of Guangdong, Hong Kong and Macao, and analyzed the competitive strategies and competitive advantages of Shenzhen, Guangdong, Hong Kong and Macao from the internal and external environment. Pan [5] compared the economic development model of Shenzhen Special Economic Zone and other regions, empirically analyzed the characteristics, environment and background of each region, and obtained the efficient non-replicability of Shenzhen Special Economic Zone. Sun [6] focused on the reform and development time series research, showing that the reform has created a model economic model for the Shenzhen Special Economic Zone, providing opportunities for exploring the world-class coordinated development of urban economy. Fu [7] started from the study

of the internal mechanism of the Shenzhen Special Economic Zone market and pointed out a way to encourage the development of the Shenzhen Special Economic Zone by strengthening the construction of ideas and culture. Duan et al. [8] from the perspective of Shenzhen future cultural industry development research, through the gray prediction model, according to the cultural development trend to predict the future role of Shenzhen cultural and creative industries in economic development, Zhang et al. [9] combined with the main components Analysis and entropy method modeling, analysis of smart city construction, Shenzhen has achieved remarkable results compared with other cities. Many studies have explored the important role of economic development in the progress of the country through historical research on economic development [10]. The study of economic development can be explained from the perspectives of resource economy, green economy and technical paradigm, so that the quantitative models established by scholars are diversified [11-12]. By establishing a four-dimensional evaluation index system of economic development level, combined with the improvement of the grey relational analysis method by the compound weighting of analytic hierarchy process, this paper evaluates the economic development of Shenzhen in the past ten years, which is helpful to find out the shortcomings in economic development and fill the economic gap. It has definite reference and reference significance for promoting the development of Shenzhen's economy.

2. Establishment of economic development level index system in shenzhen

There are numerous indicators for evaluating the level of economic development. This paper divides the evaluation index system of Shenzhen's economic development level into four aspects through reference [13-14], and analyzes the four dimensions of the economic development index system on three levels.

Target layer: Shenzhen's economic development level, marked A in the model.

Criteria layer: The subdivision of Shenzhen's economic development level mainly involves four aspects of economic development: economic total B_1, economic quality B_2, economic speed B_3, and economic efficiency B_4.

Indicator layer: The B_1 level of economic aggregate mainly includes three indicators: regional GDP C_1, agricultural total output value C_2, and industrial gross output value C_3. The economic speed B_2 level mainly includes three indicators: the provincial GDP growth rate C_4, the agricultural output value growth rate C_5, and the industrial output value growth rate C_6. The B_3 level of economic quality mainly includes three indicators: the per capita disposable income of residents of C_7 and the resident Engel coefficient C_8. The economic efficiency B_4 level mainly includes two indicators: the contribution rate of the tertiary industry C9 and the contribution rate of the secondary industry C10. as show in table 1.

Table 1 Shenzhen Economic Development Level Evaluation Index System

Shenzhen Economic Development Level Evaluation Index System A	Economic aggregate B_1	GDP C_1
		Gross agricultural output value C_2
		Industrial output C_3
	Economic speed B_2	Gross regional product growth rate C_4
		Agricultural output growth rate C_5
		Industrial output growth rate C_6
	Economic quality B_3	Resident per capita disposable income C_7

		Engel coefficient of urban residents C_8
	Economic efficiency B_4	Contribution rate of the tertiary industry C_9
		Secondary industry contribution rate C_{10}

3. Determination of grey model of economic development level of shenzhen

3.1 AHP determines the weight

When the AHP is implemented to analyze the decision problem, a hierarchical model that can reflect the system's essential attributes and internal relations is constructed. The same layer of elements not only plays a constraint role on the next layer of elements, but is also restricted by the previous layer of elements. Then the judgment matrix is constructed, which represents the comparison of the relative importance between the local level element and the upper level element. The judgment matrix used for pairwise comparison is the basis of the AHP method. According to table 2 and the scale method of 1-9, the judgment matrix $A=(a_{ij})_{n\times n}$ is constructed.

Table 2 Scale and its meaning

Scale	Meaning
1	Two elements are equally important to an attribute
3	two elements are important to one attribute, one element is slightly more important than another
5	two elements are important to one attribute, one element is more important than another
7	Two elements are important to one attribute, one element is stronger than the other
9	two elements are important to one attribute, one element is more important than another
2, 4, 6, 8	Indicates the scale when the compromise between two adjacent scales
Upper scale countdown	Element i has a scale of element j for a_{ij} ,and vice versa $1/a_{ij}$

Calculate according to the sum and product method, and use $C.R=C.I/R.I$ expand the consistency test. When $C.R\le 0.10$, pass the test and the calculation steps are as follows:

The judgment matrix A is normalized by column to obtain a matrix.

$$Q=(q_{ij})_{n\times n},\ \ q_{ij}=a_{ij}/\sum_{k=1}^{n}a_{kj} \tag{1}$$

Add the elements of matrix Q by rows to get the vector

$$a=(\alpha_1,\alpha_2,\cdots\alpha_n)^T,\ \ a_{ij}=\sum_{j=1}^{n}q_{ij} \tag{2}$$

Normalized processing

$$:w_i=\alpha_i/\sum_{k=1}^{n}\alpha_k \tag{3}$$

Maximum eigenvalue:

$$\lambda_{\max}=\frac{1}{n}\sum_{i=1}^{n}\frac{(AW)_i}{w_i} \tag{4}$$

Consistency test on the judgment matrix

$$C.I = (\lambda - n)/(n-1) \quad (5)$$

$$C.R = C.I / R.I \quad (6)$$

In equation (6), $R.I$ can be obtained by looking up Table 3.

Table 3 Average random consistency indicator value of AHP method

Order	1	2	3	4	5	6	7
$R.I$	0	0	0.52	0.89	1.12	1.26	1.36

According to the expert questionnaire survey, the weight of each index of the evaluation index system of shenzhen's economic development level was determined, and a judgment matrix was constructed, as shown in table 4-8.

Table 4 A-B judgment matrix

A	B_1	B_2	B_3	B_4
B_1	1	2	1/6	2
B_2	1/2	1	2	1/2
B_3	6	1/2	1	2
B_4	1/2	2	1/2	1

Table 5 B_1-C judgment matrix

B_1	C_1	C_2	C_3
C_1	1	3	3
C_2	1/3	1	2
C_3	1/3	1/2	1

Table 6 B_2-C judgment matrix

B_2	C_4	C_5	C_6
C_4	1	3	3
C_5	1/3	1	1
C_6	1/3	1	1

Table 7 B_3-C judgment matrix

B_3	C_7	C_8
C_7	1	1/2

C_8	2	1

Table 8 B_4-C judgment matrix

B_4	C_{10}	C_{11}
C_{10}	1	4
C_{11}	1/4	1

calculate the weight according to the comparison matrix.

According to the formula (1), (2) and (3), the weight and comprehensive weight of each evaluation index are obtained, as shown in table 9.

Table 9 Evaluation index weights

Target layer	Criteria layer	w_B	indicator layer	w_C	w
A	B_1	0.22	C_1	0.59	0.1298
			C_2	0.25	0.055
			C_3	0.16	0.0352
	B_2	0.22	C_4	0.6	0.132
			C_5	0.2	0.044
			C_6	0.2	0.044
	B_3	0.37	C_7	0.33	0.1221
			C_8	0.67	0.2479
	B_4	0.19	C_9	0.8	0.152
			C_{10}	0.2	0.038

calculate the maximum eigenvalue

The maximum eigenvalue $\lambda_{\max}$ of the judgment matrix is calculated according to equation (4)

Check the consistency of the criterion layer:

$$AW = \begin{bmatrix} 1 & 2 & 1/6 & 2 \\ 1/2 & 1 & 2 & 1/2 \\ 6 & 1/2 & 1 & 2 \\ 1/2 & 2 & 1/2 & 1 \end{bmatrix} \times \begin{bmatrix} 0.22 \\ 0.22 \\ 0.37 \\ 0.19 \end{bmatrix} = \begin{bmatrix} 1.10 \\ 1.17 \\ 2.18 \\ 0.93 \end{bmatrix}$$

$$\lambda_A = \frac{1}{4}\left(\frac{1.10}{0.22} + \frac{1.17}{0.22} + \frac{2.18}{0.37} + \frac{0.93}{0.19}\right) = 4.07$$

Check the consistency of the index layer (because there are only two economic indicators for the economic benefit index layer, there is no consistency problem)

$$B_1W = \begin{bmatrix} 1 & 3 & 3 \\ 1/3 & 1 & 2 \\ 1/3 & 1/2 & 1 \end{bmatrix} \times \begin{bmatrix} 0.59 \\ 0.25 \\ 0.16 \end{bmatrix} = \begin{bmatrix} 1.82 \\ 0.77 \\ 0.48 \end{bmatrix}$$

$$\lambda_{B_1}=\frac{1}{3}\left(\frac{1.82}{0.59}+\frac{0.77}{0.25}+\frac{0.48}{0.16}\right)=3.05$$

$$B_2W=\begin{bmatrix}1 & 3 & 3\\ 1/3 & 1 & 1\\ 1/3 & 1 & 1\end{bmatrix}\times\begin{bmatrix}0.6\\ 0.2\\ 0.2\end{bmatrix}=\begin{bmatrix}1.8\\ 0.6\\ 0.6\end{bmatrix}$$

$$\lambda_{B_2}=\frac{1}{3}\left(\frac{1.8}{0.6}+\frac{0.6}{0.2}+\frac{0.6}{0.2}\right)=3$$

Consistency check

According to formula (6), $C.R$ of each judgment matrix is obtained

$$C.R_A=\frac{0.07/3}{0.89}=0.026$$

$$C.R_{B_1}=\frac{0.05/2}{0.52}=0.048$$

$$C.R_{B_2}=0$$

$$C.R_{B_3}=\frac{0.06/2}{0.52}=0.058$$

It can be seen from above that $C.R$ is all less than 0.1, so all judgment matrices have passed the consistency test.

3.2 Improved grey correlation

To make a comprehensive evaluation of shenzhen's economic development level, grey relational analysis is passed in this paper. Grey relational analysis indicates the degree of correlation between two things, namely the degree of correlation between factors, and quantitatively describes the relative changes between factors. Data are the basis for the correlation analysis. According to the above index system, the statistical yearbook of shenzhen from 2007 to 2017 was reviewed and the above index values from 2006 to 2016 were obtained as showed in table 10.

It is assumed that there are m plans to be selected, and each has n selection indexes, with year I as row standard, evaluation index j as a column standard and original matrix $A=(a_{ij})_{m\times n}$ as column standard. In order to eliminate the limitation of different units of original data, it is necessary to carry out dimensionless processing on the original data of each index. The results are shown in table 11, set $x_{\max}$ as the optimal reference index of the matrix, $x_{\max}=\{x_0(k)|k=1,2,\cdots,n\}$ and $x_i=\{x_i(k)|i=1,2,\cdots,m;k=1,2,\cdots,n\}$ as the comparison series, and obtain the grey correlation coefficient of $x_i(k)$ and $x_0(k)$

$$\xi_{0i}(k)=\frac{[\min\limits_i(\min\limits_k|x_0(j)-x_i(k)|)+p\max\limits_i(\max\limits_k|x_0(k)-x_i(k)|)]}{[|x_0(k)-x_i(k)|+p\max\limits_i(\max\limits_k|x_0(k)-x_i(k)|)]} \tag{7}$$

Where $0<p<1$, this paper takes $p=0.5$, Considering the particularity of the time series, 2016 data is excluded, and the indicators for 2006-2015 are used as the comparison series. The calculated results are shown in Table 12.

Combining the analytic hierarchy process with the grey relational analysis, based on the effective combination of the two methods, a more scientific and comprehensive comprehensive evaluation method is proposed. The improved grey correlation degree is determined as follows:

$$r_{0i}=\sum_{k=1}^{n}\xi_{0i}(k)w(k) \tag{8}$$

Which represents the w determined by AHP. $w = w(k)$, The final results obtained by calculation are shown in Table 13.

Table 10 Data for each indicator for 2006-2016

index / times	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
2006	58135624	180017	122784801	0.174	-0.207	0.207	28218	38.0	47.8	52.6
2007	68015706	171380	143647764	0.170	-0.050	0.170	30611	37.5	49.1	51.0
2008	77867920	187859	162837576	0.145	0.096	0.134	31928	37.1	48.3	51.8
2009	82902842	154760	158286329	0.065	-0.214	-0.029	32476	35.0	55.9	44.2
2010	97733062	150467	188796600	0.179	-0.029	0.193	35107	35.5	41.0	59.0
2011	115158598	152533	212730916	0.178	0.014	0.127	36505	36.7	45.6	54.4
2012	129714672	148572	223089847	0.126	-0.027	0.049	40742	36.3	65.9	34.1
2013	145726689	139479	240440285	0.123	-0.065	0.078	44653	36.1	58.2	41.9
2014	160018207	129156	258099411	0.098	-0.080	0.073	40948	33.1	60.2	39.8
2015	175028634	159515	26 080844	0.094	0.235	0.031	44633	32.0	62.9	37.1
2016	194926012	167329	285477743	0.114	0.049	0.073	48695	30.5	63.6	36.4

Table 11 Standardized processed data

index / times	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
2006	0	0.866	0	0.956	0.016	1	0	1	0.273	0.743
2007	0.072	0.719	0.128	0.921	0.365	0.843	0.117	0.933	0.325	0.679
2008	0.144	1	0.246	0.702	0.69	0.691	0.181	0.88	0.293	0.711

2009	0.181	0.436	0.218	0	0	0	0.208	0.6	0.598	0.406
2010	0.289	0.363	0.406	1	0.412	0.941	0.336	0.667	0	1
2011	0.417	0.398	0.553	0.991	0.508	0.661	0.405	0.827	0.185	0.815
2012	0.523	0.331	0.617	0.525	0.416	0.331	0.612	0.773	1	0
2013	0.64	0.176	0.723	0.509	0.332	0.453	0.803	0.747	0.691	0.313
2014	0.745	0	0.832	0.289	0.298	0.432	0.622	0.347	0.771	0.229
2015	0.855	0.517	0.881	0.254	1	0.254	0.802	0.2	0.880	0.12
2016	1	0.65	1	0.430	0.586	0.432	1	0	0.908	0.092

Table 12 Correlation coefficient of each indicator for 2006-2015

index / times	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
2006	0.333	0.698	0.333	0.487	0.467	0.468	0.333	0.333	0.441	0.434
2007	0.360	0.879	0.364	0.505	0.693	0.549	0.362	0.349	0.462	0.460
2008	0.369	0.588	0.399	0.648	0.828	0.659	0.379	0.362	0.448	0.447
2009	0.379	0.700	0.390	0.538	0.460	0.536	0.387	0.455	0.617	0.614
2010	0.413	0.635	0.457	0.467	0.742	0.500	0.430	0.428	0.355	0.355
2011	0.461	0.665	0.528	0.471	0.865	0.686	0.457	0.377	0.409	0.409
2012	0.512	0.611	0.566	0.840	0.746	0.832	0.563	0.393	0.845	0.845
2013	0.581	0.513	0.644	0.864	0.663	0.960	0.717	0.401	0.697	0.693
2014	0.662	0.435	0.749	0.780	0.635	1	0.569	0.590	0.785	0.795
2015	0.775	0.790	0.808	0.740	0.547	0.737	0.716	0.714	0.947	0.947

Table 13 Gray correlation degree of Shenzhen's economic development level from 2006 to 2015

times	R	sequence
2006	0.406	10
2007	0.446	9
2008	0.447	8
2010	0.466	7
2011	0.472	6
2009	0.493	5
2012	0.627	4
2013	0.631	3
2014	0.676	2
2015	0.771	1

The results of the comprehensive assessment of the overall level of economic development can be obtained:

2015>2014>2013>2012>2009>2011>2010>2008>2007>2006。

4. Conclusion

1. As can be seen from Table 12, overall economic growth, economic speed and profitable quality of Shenzhen have shown a steady growth trend in 2006-2016. Although there has been a decline in some years, the overall tendency is that it continues to rise. Status.

2. The gross domestic product and the growth rate are very obvious. This shows that the Shenzhen economy has continued to develop since the reform and opening up 40 years ago. The economic level has been continuously improved, and the industrial production value has generally increased. However, the growth rate of industrial output value is slightly later. This has also shown that Shenzhen's industrial economy accounts for a large proportion of the overall economic development; the people's living standards are constantly improving, and the disposable income of residents has also increased with time, and the resident Engel coefficient has shown a declining trend. So far, it has reached a level of 30% relative affluence. It can be seen that the development of Shenzhen has brought about a rapid increase in the living of the residents; the development of the tertiary industry has shown a sharp increase, and it has greatly responded to the call of the era of "Made in China 2025" and vigorously developed. Manufacturing service transformation.

3. It can be seen from Table 13 that the correlation index of Shenzhen's economic development show a stable growth pattern. In 2009, there were huge gains under the stimulus of monetary policies, and there was a jump in growth. The comprehensive economic development level achieved the best results in 2015. The grey correlation degree reached 0.771. The research results show that the development of Shenzhen's economic level in four dimensions shows a state of continuous growth. In 2006, the comprehensive economic development level was the minimum, and the gray correlation degree was 0.406. Overall, Shenzhen The level of inclusive economic development has fluctuated over the past decade, but the upward trend in development is radical.

Shenzhen's progress in reform is obvious to all. In order to let Shenzhen continue to maintain the pace of economic growth, this paper gives the following suggestions: First, accelerate the construction of innovation-driven policies, adopt various incentives to lower the threshold of innovation, and further increase the total economic volume; The establishment of an innovation support system will lead to the convergence of national and even international innovation achievements to Shenzhen and accelerate the economic speed. Third, provide an effective market environment for innovation activities, regulate behavior through administrative and legislative means, and encourage enterprises to depend on intellectual property rights such as innovation and patents. Gain sustained growth momentum and improve economic quality. Fourth, seize the lifeblood of the industrial economy, accelerate the transformation of manufacturing-to-service-oriented enterprises, and continuously improve fiscal efficiency.

References

[1] Zhang S P. Shenzhen and China's Reform and Opening up for 40 Years[J]. Special Zone Economy,2018(06):10-16.

[2] Gu Y, Li S. New Ideas for Shenzhen's Innovation and Development in the New Era[J].Macroeconomic Management,2018(01):83-88+92.

[3] Yi X. Practice Exploration of Transforming Economic Growth Mode: Shenzhen Illustration[J].Reform,2018(08):120-128.

[4] Deng Z X.The Development Strategy of Shenzhen in the Strategy of Guangdong, Hong Kong and Macao Dawan District——From Competitive Strategy to Competitive Advantage[J]. Reformation & Strategy, 2018, 34(07):33-38.

[5] Pan F. Comparative Study of Shenzhen Special Economic Zone, Pudong New Area and Xiong'an

New District[J]. Reform of Economic System, 2017(06):46-51.
[6] Sun C X. The Exploration of System Reform in Shenzhen Special Economic Zone and Its Demonstration Value [J]. Reform, 2018(05): 18-26.
[7] Fu J M. Shenzhen Experiment: The Innovative Practice of Marxism in China[J]. Theory and Reform,2018(04):25-33.
[8] Duan J, Zhang J. Research on the Contribution of Shenzhen Cultural and Creative Industry Development to Economic Growth Based on Grey Prediction[J]. China Population,Resources and Environment, 2014, 24(S1):457-460.
[9] Zhang N, Sheng W. Research on the Status Quo of Smart City Development Based on Principal Component Analysis and Entropy Method[J].Journal of Urban Studies,2018,39(03):30-35
[10] Schumpeter J A. Theory of economic development[M]. Routledge, 2017.
[11] Zaman A U, Lehmann S. The zero waste index: a performance measurement tool for waste management systems in a 'zero waste city'[J]. Journal of Cleaner Production, 2013, 50: 123-132.
[12] Acemoglu, Daron, Camilo Garcia-Jimeno, James A. Robinson. State capacity and economic development: A network approach[J]. American Economic Review ,2015,105(8) : 2364-2409.
[13] Wei M, Li S Z. Construction and Measurement of China's Economic Growth Quality Evaluation System under the New Normal[J]. Economist, 2018(04):19-26.
[14] Shi Z, Li Z J, Liu D. Construction of Green Economic Evaluation Index System Based on Grey Correlation- Rank Correlation[J]. Statistics & Decision, 2018,34(11):28-32.