Comparative Studies between the Regional Economic Growth Levels Based on the Three-Stage Weight Dynamic Comprehensive Evaluation

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Abstract. This paper proposes a dynamic comprehensive evaluation method based on three times weight. Firstly, this paper determines the index weight based on the twice stage difference driving features. Then it introduces the relative balance coefficient to calculate the comprehensive evaluation value. This method has the following characteristics: 1) The comprehensive evaluation result is totally based on the information provided by the evaluating indicator system, without the influence from subjective factors; 2) The results have direct comparability among different evaluation systems at each time; 3) Motivation or punishment are the characteristics of this method. This approach has been applied to an empirical study of the regional economic growth level during the years of 2001 and 2011. Finally this paper makes related suggestions to the economic development of eight domestic economic regions.

Keywords: Twice stage difference features; Relative balance coefficient; Three times weight. Dynamic comprehensive evaluation. Regional economic growth

1 Introduce

The economic development level of every region in China is in disequilibrium because there are variously economic and social differences in the growth rate and configuration mode of the production factors. For the issues above, the government has significantly improved the economic development levels of western and northeastern China, by refining and adjusting the regional development strategies like western development, Revitalizing old industrial base of northeastern China. But comparing with the other regions, there is still a great advantage in the developed regions of eastern and middle China because of their strong economic base. And the differences are still very obvious if we talk about the specific provinces, cities and autonomous regions. Comprehensive evaluation, analysis and comparison on the economic development levels of each region in China are of great significance to enhance the Macro-control and promote the coordinated development of national economy.

The domestic research about regional economic development is primarily in the 20th century, 90 years later. Most of the scholars adopt various statistics techniques to analysis the difference change law of regional economic [1-3]; DEA was used for evaluating the difference of regional economic development of 12 cities in Liaoning

by liangjian and mojianfang [4-6]； Yangzhuxin put forward those who be based on the collect bisect analyze to be able to evaluate the economic development of Bohai sea [6]. Yuebing proposed a uniform approximation comprehensive evaluation method to estimate the level of economic development of 12 provinces and cities of china [7]. Existing research focus on difference analysis on regional economic development, there is little research that is directed to the change of regional economic development level for a period of time, For this reason the paper establish a set of complete scientific and comprehensive system of evaluation indicators, and proposes a dynamic comprehensive evaluation method based on three times weight, and then compared the economic development of 31 provinces, autonomous regions and municipalities during the years of 2001 and 2011, finally, the paper ranked the cities according to their economic development level.

2 Index selection

In according with the principle of systematic and comprehensive, reliability and easy to operate, an evaluation index system, which contains seven indexes, was established as shown in table 1:

Table 1. Evaluation index system

Index code	Index	Unit
x1	Regional GDP	Million Yuan
x2	Regional Add Value of the Tertiary Industry	Billion Yuan
x3	Per-capita Disposable Income of Urban Residents	Yuan/person
x4	Per-capita Disposable Income of Rural Residents	Yuan/person
x5	Region Tax Revenue	Billion Yuan
x6	Foreign Trade	Billion Yuan
x7	Social Productivity (region GDP/region employed person)	Billion Yuan/ Million Person

We choose 2387 data series during the year of 2001 and 2011, all the data from “china statistical yearbook”.

3 A Dynamic Comprehensive Evaluation Method based on Three Times Weight

In the real world, data series which own large amount of data according to the order of time like a data cartridge, we call it multi-dimensional time series [8-9], Dynamic comprehensive evaluation is a problem base on multi-dimensional time series, it generally denoted as:

$$y_i(t_k) = f(\omega_1(t_k), \omega_2(t_k), \cdots, \omega_m(t_k); x_{i1}(t_k), x_{i2}(t_k), \cdots, x_{im}(t_k)), (k = 1, 2, \cdots, N) \quad (1)$$

$y_i(t_k)$ is the comprehensive evaluation value of system s_i at the time of t_k.

The paper proposed a dynamic comprehensive evaluation method based on three times weight, the method follow the principle of greatest extends reflects the difference between the object as described in the following procedure:

3.1 The weight determination process based on the twice variance drive

a）Handling dimensionless. Without loss of generality, assume the index of index set $x_1, x_2, \cdots, x_m$ are all extra-large, in order to combat the effects of different dimension and different type, need carry out the dimensionless treatment with the data as below:

$$x_{ij}^{/}(t_k) = \frac{x_{ij}(t_k) - x_{ij}^{\min}(t_k)}{x_{ij}^{\max}(t_k) - x_{ij}^{\min}(t_k)} (i = 1,2,\cdots,n; j = 1,2,\cdots,m; k = 1,2,\cdots,r) \tag{2}$$

b）Determine the weight coefficients ω_{jk} of each year by using mean square error. The basic principle of this method is the weight coefficient depend on the relative dispersion degree of the evaluation object, the greater the dispersion degree of index values, the greater the weight coefficient [10]. Therefore, the method reflects the importance of index by using mean square error, operation step as fellows:

$$\omega_{jk} = \frac{R(X_j(t_k))}{\sum_{j=1}^{m} R(X_j(t_k))} \tag{3}$$

c）Determine the weight coefficient w_j: If there were obvious difference between the index value of the x_j at moment t_k and the index value of the other moment, the weight at same time should play a biggish role in the process of evaluation in order to expose this difference. The fluctuant circumstance of index x_j at moment t_k(k=1,2,L,N) can be boiled down to a formula:

$$\theta_{jk} = \frac{\sum_{s \neq k} \cos\langle x_j(t_k), x_j(t_s) \rangle}{N-1} \tag{4}$$

The bigger the θ_{jk}, the index value at moment t_k(k=1,2,L,N) closer to the index at other time, and the moment play a small role in the whole evaluation process, so the overall weight of the index x_j can be expressed as:

$$\omega_j = \sum_{k=1}^{N} \frac{1}{\theta_{jk}} \omega_{jk} \Big/ \sum_{j=1}^{m} \sum_{k=1}^{N} \frac{1}{\theta_{jk}} \omega_{jk} \tag{5}$$

The ω_j as a final weight value of index, the bigger the ω_j, the greater index influence, but rather the contrary.

3.2 Result based on the three stage weight dynamic comprehensive evaluation

When analyze the overall situation of s_i, we expect the comprehensive evaluation value in the period of $[t_1, t_N]$ of the bigger the better [11], but the fluctuation of s_i in this period as small as possible.

a) Determine the synthetic evaluation indexes by using method based on twice-weighted. To determined the weight by using the method shows above, and built a synthesizing evaluation function at some point such as $t_k(k=1,2,\cdots,N)$:

$$y_i(t_k)=\sum_{j=1}^{m}\omega_j x_{ij}(t_k), k=1,2,\cdots,N; i=1,2,\cdots n \tag{6}$$

The comprehensive evaluation value, is calculated from the above formula has direct comparability. s_i has different 'performance' in different moment. During the study process on the execution status of the entire system, in order to embody the thinking about thick thin now thou and emphasize the differences between different moments, the comprehensive evaluation index is defined as [8]

$$h_i=\sum_{k=1}^{N}\exp\{\lambda t_k\} y_i(t_k), i=1,2,\cdots,n \tag{7}$$

λ is the time discount factor. In order to avoid the randomness of λ value, it is defined that $\lambda=(2N)^{-1}$

b）Introduce the 'relatively balanced coefficient' to implement triple weighting. In the calculation process of comprehensive evaluation index, the situation like $h_i=h_j(i\neq j)$ may happened because of the appearance of complementary. At this stage, the paper using the reciprocal of the coefficient of variation to describe the balance of the system:

$$JH^*_i=n\cdot\frac{JH_i}{\sum_{i=1}^{n}JH_i} \tag{8}$$

$$JH_i=\begin{cases}\dfrac{h_i}{s_i},(s_i\neq 0)\\ \max\{JH_d\}+c,(s_i=0;s_d\neq 0)\end{cases},(i=1,2,\cdots,n) \tag{9}$$

$$h_i=\frac{1}{N}\sum_{k=1}^{N}h_{ik}$$

$$s_i=\sqrt{\frac{\sum_{k=1}^{N}(h_{ik}-h_i)^2}{N-1}}$$

Formula 8/9 shows that the bigger JH_i, the smaller fluctuation of the system value, which means the system development is more balanced. Otherwise, the bigger fluctuation means the development is more imbalanced. We should increase the comprehensive evaluation value in some extent to encourage the system, which

developed balanced. While for the system of lopsided development, we need to reduce their comprehensive evaluation value for punishment.

c）An evaluation model based on relatively balanced coefficient. On the basis of getting relatively balanced coefficient, we make the aggregation once more:

$$h_i^* = (\lambda_1 + \lambda_2 \cdot JH_i^*) \cdot h_i \tag{10}$$

$$\lambda_1 + \lambda_2 = 1 \tag{11}$$

$$\lambda_2 = \frac{\sum_{i=1}^{n} \left| JH_i^* - 1 \right| \cdot h_i}{\sum_{i=1}^{n} h_i}$$

The s_i is sorted from big to small according to the value of h_i^*. The sorting result reflects both the comprehensive evaluation result in each year. And meanwhile, the comprehensive evaluation result given from this method is completely based on the information provided by evaluation indexes.

4 Instance

4.1 The weight determination process based on the twice variance drive

To determine the weight for each economic index from the 31 provinces, cities and autonomous regions from 2001-2011， we further discuss the change degree of the development trends from each economic index between different years (see table 2).

Table 2a. The calculations of index weights and change degree

	The Economic Index Weight of 2001-2011						
	X1	X2	X3	X4	X5	X6	X7
2001	0.167	0.130	0.134	0.137	0.139	0.164	0.129
2002	0.173	0.124	0.113	0.144	0.142	0.169	0.136
2003	0.164	0.127	0.136	0.140	0.135	0.169	0.129
2004	0.164	0.130	0.128	0.148	0.134	0.170	0.128
2005	0.169	0.125	0.126	0.156	0.134	0.162	0.128
2006	0.149	0.128	0.145	0.157	0.136	0.149	0.136
2007	0.150	0.131	0.141	0.154	0.137	0.151	0.136
2008	0.149	0.134	0.134	0.156	0.137	0.157	0.133
2009	0.153	0.136	0.124	0.155	0.140	0.158	0.133
2010	0.149	0.135	0.130	0.153	0.139	0.157	0.138
2011	0.148	0.143	0.129	0.149	0.141	0.153	0.136

Table 2b. The calculateions of index weights and change degree - The Average Cosine Value

	X1	X2	X3	X4	X5	X6	X7
2001	0.995	0.970	0.963	0.983	0.996	0.967	0.983
2002	0.996	0.978	0.963	0.990	0.997	0.968	0.985
2003	0.997	0.983	0.933	0.993	0.998	0.973	0.989
2004	0.997	0.984	0.962	0.995	0.998	0.976	0.991
2005	0.997	0.983	0.965	0.994	0.998	0.980	0.991
2006	0.997	0.985	0.953	0.994	0.998	0.982	0.991
2007	0.997	0.985	0.961	0.995	0.998	0.983	0.992
2008	0.997	0.983	0.968	0.995	0.998	0.981	0.992
2009	0.997	0.981	0.954	0.994	0.998	0.974	0.990
2010	0.996	0.981	0.968	0.993	0.997	0.965	0.985
2011	0.996	0.975	0.968	0.990	0.995	0.959	0.983

Based on the basic principle of twice variance drive, this paper reduces the economic indicator weights with the same development trends and increases the indicator weights of those with big changes. These paper determines the comprehensive weights for each kind of economic indicators like that shown in next table:

Table 3. Comprehensive weight values of every kind of economic indicators

	X1	X2	X3	X4	X5	X6	X7
Weight	0.1558	0.1314	0.1342	0.1487	0.1358	0.1616	0.1324

The comprehensive evaluation values of each region from 2000 to 2010 are calculated by using linear weighted comprehensive method. The value is shown in table 4.

4.2 Introduce the relatively balanced coefficient to make triple weighting

Considering the fluctuation status of each province, city and autonomous region from 2001 to 2011, we calculate the relatively balanced coefficient and the overall evaluation. The ranking of overall evaluation values are shown in table 5:

5 Research Findings and Policy recommendations

As the overall evaluation result, the economic developments among the eastern, central and western China are very imbalanced. The developed areas mainly concentrate in eastern area while the undeveloped areas mainly concentrate in the western area. All of the provinces, cities and autonomous regions with top 10 economic development level are from the eastern area. On the contrary, 8 of the 12 regions from western area are in the last 10 places. The other 4 regions are Inner

Table 4a. Comprehensive evaluation of economic development in each region (2001-2011)

Regions	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Beijing	0.44	0.46	0.47	0.47	0.47	0.53	0.52	0.53	0.51	0.51	0.53
Tianjin	0.29	0.31	0.3	0.31	0.31	0.3	0.31	0.31	0.33	0.35	0.37
Hebei	0.32	0.32	0.31	0.3	0.31	0.28	0.29	0.3	0.32	0.31	0.32
Shanxi	0.12	0.11	0.12	0.13	0.14	0.15	0.15	0.16	0.18	0.17	0.18
Inner Mongolia	0.11	0.11	0.13	0.15	0.16	0.17	0.2	0.22	0.25	0.27	0.28
Liaoning	0.36	0.36	0.35	0.32	0.32	0.32	0.32	0.34	0.38	0.37	0.41
Jilin	0.16	0.17	0.16	0.16	0.16	0.14	0.16	0.18	0.2	0.2	0.2
Heilongjiang	0.23	0.24	0.23	0.22	0.21	0.17	0.16	0.17	0.19	0.18	0.19
Shanghai	0.73	0.72	0.73	0.73	0.74	0.72	0.7	0.7	0.69	0.68	0.66
Jiangsu	0.56	0.56	0.58	0.6	0.62	0.6	0.62	0.65	0.67	0.68	0.71
Zhejiang	0.51	0.54	0.57	0.6	0.58	0.57	0.57	0.56	0.54	0.53	0.56
Anhui	0.2	0.2	0.19	0.18	0.18	0.16	0.17	0.19	0.21	0.21	0.23
Fujian	0.35	0.34	0.32	0.31	0.31	0.26	0.27	0.29	0.31	0.29	0.31
Jiangxi	0.14	0.14	0.14	0.14	0.15	0.14	0.14	0.14	0.16	0.16	0.18
Shandong	0.53	0.52	0.53	0.55	0.57	0.55	0.57	0.56	0.59	0.58	0.59
Henan	0.27	0.27	0.27	0.27	0.28	0.27	0.29	0.3	0.33	0.32	0.33
Hubei	0.28	0.28	0.28	0.26	0.24	0.2	0.21	0.23	0.25	0.24	0.26
Hunan	0.24	0.23	0.23	0.21	0.22	0.21	0.21	0.22	0.24	0.24	0.25
Guangdong	0.78	0.76	0.76	0.73	0.72	0.73	0.72	0.72	0.72	0.71	0.71
Guangxi	0.14	0.14	0.14	0.13	0.13	0.12	0.13	0.13	0.16	0.15	0.16
Hainan	0.09	0.09	0.08	0.08	0.07	0.06	0.06	0.06	0.08	0.06	0.07
Chongqing	0.17	0.14	0.15	0.15	0.15	0.13	0.13	0.14	0.19	0.16	0.17
Sichuan	0.24	0.26	0.26	0.25	0.24	0.22	0.22	0.24	0.26	0.27	0.29
Guizhou	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.07	0.08	0.07	0.08
Yunnan	0.17	0.14	0.14	0.13	0.14	0.12	0.12	0.12	0.13	0.13	0.14
Tibet	0.03	0.03	0.1	0.06	0.06	0.04	0.02	0.02	0.02	0.01	0.01
Shaanxi	0.13	0.13	0.13	0.13	0.13	0.13	0.14	0.15	0.18	0.18	0.2
Gansu	0.08	0.08	0.07	0.06	0.06	0.06	0.06	0.07	0.08	0.07	0.07
Qinghai	0.04	0.05	0.05	0.05	0.05	0.03	0.04	0.04	0.06	0.05	0.06
Ningxia	0.04	0.05	0.04	0.04	0.05	0.05	0.06	0.06	0.09	0.08	0.09
Xinjiang	0.14	0.14	0.14	0.13	0.12	0.11	0.11	0.11	0.13	0.11	0.13

Mongolia, Sichuan, Yunnan and Xinjiang, whose ranks are also in the backward places 18th, 13th, 19th and 20th respectively. For the 11 years development, the economic development level of Jiangsu province is always ranked at the 3rd place. The economic development level of Beijing city is always ranked at the 6th place. The economic development level of

Liaoning province is always ranked at the 7th. The sequences of Tianjin, Inner Mongolia, Henan and Sichuan are stably rising up. In addition to Inner Mongolia, the rising rates of the other regions are very small. Besides, the changes of the regional economic status in China have the character like ‘rigid body translation’. So it is very

Table 5. The sorting result of the dynamic comprehensive evaluation result for each region's

Regions	Relatively Balanced Coefficient	Evaluation Value	Rank Results
Beijing	0.950678	0.647108	6
Tianjin	0.863093	0.401213	10
Hebei	1.226271	0.431684	9
Shanxi	0.615723	0.170316	25
Inner Mongolia	0.407585	0.206644	18
Liaoning	0.919504	0.448882	8
Jilin	0.759644	0.208418	17
Heilongjiang	1.737191	0.310575	14
Shanghai	1.645028	1.109446	2
Jiangsu	0.847437	0.791767	4
Zhejiang	1.278549	0.792838	3
Anhui	0.819529	0.236511	16
Fujian	1.496676	0.456686	7
Jiangxi	0.764263	0.177665	22
Shandong	1.014575	0.743778	5
Henan	0.844111	0.366211	11
Hubei	1.302635	0.351772	12
Hunan	1.017027	0.297138	15
Guangdong	1.56975	1.125752	1
Guangxi	0.851985	0.173828	23
Hainan	1.314329	0.098503	26
Chongqing	0.82172	0.185603	21
Sichuan	0.93464	0.321178	13
Guizhou	0.776897	0.078473	28
Yunnan	1.537235	0.198961	19
Tibet	0.251214	0.031996	31
Shaanxi	0.580093	0.170543	24
Gansu	1.107278	0.088641	27
Qinghai	0.64729	0.052347	30
Ningxia	0.422798	0.061456	29
Xinjiang	1.675251	0.19069	20

difficult to break the existed economic pattern because of the forming from a lot of years.

The southeast coastal area of China consists of Guangdong, Fujian and Hainan provinces. Unlike the development of eastern coastal area, the economic development of this area is very imbalanced. The comprehensive ranking of Guangdong province is No.1 while the ranking of Hainan province is only 26. So for these 2 backward provinces, especially for Hainan province, the major issue is how to utilize the overseas social resources and high-level openness from its neighbors Hongkong, Macao and Taiwan to accelerate the economic development.

The northern coastal area of China consists of 2 provinces (Hebei and Shandong) and 2 cities (Beijing and Tianjin). These 4 cities and provinces are always in steady development status (maximum ranking difference) during the 11 years. And finally, their comprehensive evaluation values are respectively ranked at the 6th, the 10th, the 9th and the 5th. This area should continue to utilize their superior geographical location, convenient transportation and developed technology, education and cultural

undertakings, in order that, it can enlarge its opening to the outside world and seek progress in stability.

The middle reaches of the Yellow River in China consists of 3 provinces and 1 autonomous region, which are Shanxi, Shanxi, Henan and Inner Mongolia. It shows that the economic development levels of these 4 areas are improved year by year in this 11 years. Especially, the economic development level of Inner Mongolia has risen to the 13th in 2010 comparing with its 25th position in 2000. In these 4 regions, the economic development mainly relies on their rich natural resources. So, accelerating the steps to open to the outside world and adjust the economic structure become the major problem without any delay. And meanwhile, Shanxi, Shanxi and Henan provinces could take the development model of Inner Mongolia as reference to promote their big progress in economic development.

The middle reaches of the Yangtze River in China consist of Hubei, Hunan, Jiangxi and Anhui provinces, whose comprehensive ranking are in lower locations. This region should vigorously develop its agricultural production, increase the degree of opening to the outside world and accelerate industry transformation. Besides, because of the large population of this region, the effective improvement of per capita economic level is also the major task in its development.

The northeastern China consists of 3 provinces, which are Liaoning, Jilin and Heilongjiang. The major issues this region faces are resources depletion and the urgent requirement of industrial structure upgrading. So this region should increase the proportion of gross product from the non-public economics and the small and medium-sized business, speed up the technological progress and improve its capacity for independent innovation, consolidate the foundation position of agriculture, improve the resource utilization, promote the foreign economic cooperation and improve the usage quality of foreign investment. During the development progress, Jilin and Heilongjiang provinces could take the development process of Liaoning province as reference. They should deepen the collaboration between provinces and promote the integration development of regional economy.

Besides, the southwestern and northwestern China consists of 5 provinces and 1 city. Because of the historical existence and excessive enlargement of the development gap with eastern region, 90% of the regional economic development in this area belongs to underdeveloped region. The problems of this region such as remote location, poor soils, bad natural conditions and large number of poor people make the western region construction as a long and difficult task. The western development provides a series of policy guarantees and funding for the economic development of western China. So we must insist carrying out the western development strategy, accelerate the infrastructure construction, strengthen the ecological protection, positively adjust the industrial structure, develop the technology and education and accelerate the talent development. Under the premise of our country's stable increase in financial resources, our country should gradually increase the support on western region and fully encourage western region's initiatives, to push on the economic development of western region with specific target and phases.

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