

Evaluation of Sustainable Development Coordinated Ability in Jing-Jin-Ji Region Based on Fuzzy Information

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Received 1 November 2014, www.cmnt.lv

Abstract

The coordinated ability of regional development is one of the significant representations of regional sustainable development. This paper adopted the statistical data and materials of each relevant department of social economy, and established the evaluation index and each level evaluation criteria of regional sustainable development. In addition, this paper also analyzed the sustainable development coordinated ability in Jing-Jin-Ji region between 2000 and 2010 by using the harmonious development evaluation model of IDC state sort in fuzzy information method. The results indicated that Beijing and Tianjin belonged to uncoordinated development between 2000 and 2004, and they gradually stepped into weak coordinated development between 2006 and 2010. However, during the research phase, Hebei province belonged to uncoordinated development all the time; compared with the coordinated ability index of Jing, Jin and Ji in 2000, those in 2010 were respectively increased by 27.86%, 8.87% and 18.51%, and the improvement of coordinated development in each province was not apparent and consistent; this paper proposed specific suggestions on the domain development of Jing-Jin-Ji region, but it is still necessary to strengthen the regional cooperation and the definition of each function is especially important. The research results provided scientific basis and guidance for the formulation and implementation of whole planning in Jing-Jin-Ji region, and also established foundation for the sustainable development of Bohai economic rim.

Keywords: Fuzzy information method; Sustainable development; Coordinated ability; Evaluation model; Jing-Jin-Ji.

1 Introduction

Economists, environmentalists, ecologists, et al all have conducted a large number of researches on the evaluation problems of sustainable development from different perspectives, such as discussion on the construction of index system [1-2], application of zoology footprint method [3] and other multiple evaluation model and methods [4-5]. However, there is still no uniform evaluation method at present. Researches on the coordinated ability of sustainable development have put forward the construct model of the concept of coordination degree [6] and conducted quantitative evaluation research on system coordination [7]. There were also researches conducted measurement and evaluation on construct model started from the perspective of system theory and provincial characteristics [8], which mostly adopted analytic hierarchy process, fuzzy evaluation, etc. The evaluation of sustainable development coordinated ability actually is the fuzzy analysis of the certainty and uncertainty among compound systems. Set pair analysis is the powerful tool for evaluating fuzzy information, which has better reliability and operability [9] and is widely used in land utilization [10], ecology health evaluation model [11],

environmental quality assessment [12] and water quality comprehensive evaluation [13].

Jing-Jin-Ji region is located in the core region of Circum-Bohai Sea region and Northeast Asia, which is considered as the economic center of northern China. It has increasingly attracted the attention of China and even the whole world. Therefore, researches on the sustainable development coordinated ability in Jing-Jin-Ji region are of great significance. This research result will also have important referential significance to the comprehensive coordinated development of similar regions.

2 Fuzzy Information Method and Evaluation

A. FUZZY INFORMATION METHOD

Fuzzy information method refers to use fuzzy mathematics to process fuzzy information, and by means of abstracting, summarizing, synthesizing and reasoning to obtain conclusion of certain precision.

Zhao Keqin put forward a kind of theory that conducts IDC quantitative analysis on the certain and uncertain problems so as to process the inaccurate and incomplete information [14]. A subsidiary that made up of two set of certain relation can be expressed by $W = (A, B)$. The nature of set pair analysis is to analyze the link and conversion of objects in certain and uncertain system

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from identical, discrepancy and contrary. identical discrepancy contrary. identical discrepancy contrary

The connection degree μ calculation formula of identical, discrepancy and contrary of two set established under the background of problems is shown as follows:

$$\mu = a + bj + cj = \left(\frac{N_1}{N}\right) + \left(\frac{N_2}{N}\right)i + \left(\frac{N_3}{N}\right)j \tag{1}$$

N , N_1 , N_2 and N_3 are respectively stand for the total characteristic number of two set, common characteristic number, mutual opposite characteristic number and not common nor opposite characteristic number in set, of which $N_3 = N - N_1 - N_2$. The normalization condition in formula (1) is $a+b+c=1$, of which a , b and c are respectively the identical degree, discrepancy degree and contrary degree of the discussed set pair under the background of specified problem. It reflects the positive, negative and uncertain trend of each set in fuzzy information, and i and j are respectively represent discrepancy mark effect and opposite mark effect. The comparison and state sorting of the numeral size of a , b and c in formula (1) is called IDC state sort. The corresponding sorting results are expressed by numbers among $[0.1, 1]$, which is called state degree (TABLE 1). The size of state degree can reflect the state degree of problems.

Evaluation method

In order to reasonably evaluate the compound system coordinated ability of region, this paper adopted the sustainable development coordinated evaluation model of IDC state sort in set pair analysis[15], and combined with the state degree of society, economic development, environmental functional lesion and the result of

coordinated ability index for conducting assessment and judgment.

When using set pair analysis theory to conduct sustainable development coordinated ability evaluation, we generally consider the certain index value of the evaluated sample as a set A_p ($p=1, 2, \dots, m$; m is number of evaluation index), and regard the certain evaluation criteria of corresponding index as another set B_q ($q=1, 2, \dots, n$; n is the number of evaluation scale). A_p and B_q constitute a set pair H (A_p, B_q), then conduct corresponding comparison on the two set in set pair. This paper took the index value of each subsystem in Jing-Jin-Ji region and index of each level prescribed in the valuation criteria of the region as two set and constitute set pair respectively. In order to meet the practicability, operability and simplicity of index selection as well as the authenticity and comparability of results, it is necessary to choose as much as possible the mean value, units of mean value and percentage to express except environmental quality index.

B. EVALUATION MODEL

As for social economical index, if we define grade i ($i=1, 2, 3$) as evaluation criteria, then the number of index N_i that conforms to the criteria of grade i is the number of common characteristics possessed by the two set in set pair. The number index that higher than grade i is the number of characteristics that both not opposite and commonly possessed by the two set. The number index that lower than i is the number of characteristics that mutually opposite in set pair. N_1 , N_2 and N_3 meet $N_1+N_2+N_3=N$. Identical degree a , discrepancy degree b and contrary degree c in the connection degree formula of social and economical development are shown in TABLE 1 when affirm different grades as evaluation criteria.

TABLE 1: The calculation of connection degree a , b and c of social an economical index

evaluation criteria	a	b	c
first grade	$N_{1/N}$	$(N_2 + N_3)/N$	0
second grade	$N_{2/N}$	$N_{3/N}$	$N_{1/N}$
third grade	$N_{3/N}$	0	$(N_1 + N_2)/N$

As for environmental index system, the number of index that conforms to the first grade is the number of characteristics that common possessed by two set in set pair. The number index that conforms to the second grade is the number of characteristics that both not opposite and commonly possessed by the two set. The number index that conforms to the third grade is the number of characteristics that mutually opposite in set pair. Therefore a , b and c in connection degree formula of environmental functional lesion are respectively calculated by $a=N_{1/N}$, $b=N_{2/N}$ and $c=N_{3/N}$. The state degree of IDC state sort determined by the relation

among a , b and c are respectively called the state degree d_s , d_e and k [15] of social, economical development and environmental functional lesion. The mutual relation among them can define the coordinated ability index I of economy, society and environment: $I = 1/(1 + ke^{d_s d_e})$ (2). In formula, d_s stands for state degree of social development; d_e stands for stated degree of economical development; k refers to state degree of environmental function lesion. When the degree of social and economic development are in their best (take $d_e=d_s=1$), and with the best ecological environmental protection (take $k=0.1$), then the coordinated ability index of the three parts can

be calculated by formula (2), that is $I=0.97$. When social economical development is in its worst (take $de=ds=0.1$), and with the worst ecological environment damage (take $k=1$), then the coordinated ability index $I=0.5$. However, when the development of the three parts are in medium degree (take $de=ds=k=0.5$), $I=0.72$. Therefore, with reference to the existed researches [16] to conduct analysis on the coordinated ability index I value when valuing de , ds and k , and correspondingly mark out the corresponding relation between the value range of I value and the coordinated ability of sustainable development. The divided sections are respectively uncoordinated section $[0.5, 0.6]$, weak coordinated section $[0.6, 0.7]$,

basic coordinated section $[0.72, 0.85]$ and highly coordinated section $[0.85, 0.97]$.

3 Empirical Researches

This paper selected Jing-Jin-Ji region as the empirical research object. The representativeness and operability of research index were considered according to the purpose and significance of researches, and all together selected 18 indexes of three types. The value of ds , de , k and I of these regions are shown in TABLE 2.

TABLE 2: Value of de , ds , k and I in Beijing, Tianjin and Hebei

Region	Year	Society				Economy				Environment				ds	de	k	I
		N_1	N_2	N_3	N	N_1	N_2	N_3	N	N_1	N_2	N_3	N				
Beijing	2000	4	2	0	6	3	3	0	6	5	0	1	6	0.1	0.6	1	0.5150
	2002	4	2	0	6	3	3	0	6	5	0	1	6	0.1	0.6	1	0.5150
	2004	4	2	0	6	2	4	0	6	3	3	0	6	0.1	1	0.8	0.5801
	2006	3	2	1	6	2	4	0	6	2	4	0	6	0.2	1	0.7	0.6357
	2008	3	0	3	6	0	6	0	6	2	4	0	6	0.3	1	0.7	0.6585
	2010	2	1	3	6	0	5	1	6	2	4	0	6	0.3	1	0.7	0.6585
Tianjin	2000	5	1	0	6	6	0	0	6	3	3	0	6	0.1	0.1	0.8	0.5580
	2002	5	1	0	6	4	2	0	6	3	3	0	6	0.1	0.1	0.8	0.5580
	2004	4	2	0	6	4	2	0	6	3	3	0	6	0.1	0.1	0.8	0.5580
	2006	3	3	0	6	3	3	0	6	3	3	0	6	0.6	0.6	0.8	0.6418
	2008	2	4	0	6	3	3	0	6	3	3	0	6	1	0.6	0.8	0.6949
2010	2	2	2	6	3	2	1	6	2	2	0	6	0.4	0.3	0.7	0.6075	
Hebei	2000	6	0	0	6	4	2	0	6	5	5	1	6	0.1	0.1	1	0.5025
	2002	6	0	0	6	4	2	0	6	6	6	0	6	0.1	0.1	1	0.5025
	2004	6	0	0	6	5	1	0	6	3	3	0	6	0.1	0.1	0.8	0.5580
	2006	6	0	0	6	4	2	0	6	3	3	0	6	0.1	0.1	0.8	0.5580
	2008	5	1	0	6	4	2	0	6	3	3	0	6	0.1	0.1	0.8	0.5580
2010	5	0	1	6	4	2	0	6	2	2	0	6	0.3	0.1	0.7	0.5955	

4 Results Analysis

A. ANALYSIS ON THE STATES OF SOCIETY, ECONOMICAL DEVELOPMENT AND ENVIRONMENTAL FUNCTIONAL DAMAGE

From TABLE 1, we can see that the economical growth is not always immediately driving the progress of society. Economy in Beijing is rapidly developing (0.6, 1) between 2000 and 2010, but the social development was behind economical development (0.1, 0.2, 0.3), which verified that there really exist certain time lag when the result of economical growth converts to social development, but social development still make progress. If this kind of tendency can stay or present obvious uptrend in future, the harmony between social and economical development is hopeful. The de and ds in Tianjin between 2000 and 2004 were lower than that in Beijing, of which both were 0.1. However, though the economical growth in Tianjin between 2006 and 2010 was not match for that in Beijing (0.3, 0.6), the results showed that social development degree was simultaneously increased with economy (0.4, 0.6, 1). From table 4, it is clear that in the 6 indexes that

represented social development in Tianjin between 2000 and 2002, 5 indexes conformed to first grade and 1 second grade. However, in 2004, 4 indexes conformed to first grade and 2 second grade; in 2006, 3 first grade and 3 second grade; in 2008, 2 and 4. In 2010, 2 indexes conformed to third degree.

Under the selected third grade of evaluation criteria and compared with 2008, ds and de of Tianjin in 2010 showed inverse growth (0.4, 0.3), which was caused by continuous following of second grade evaluation criteria when the index number of third grade increased (N_3 was 2, 1) because of rapid economical growth. If first grade and third grade criteria are respectively used for calculation, then the ds and de of two years are both 0.7 (under first criteria) and 0.1 (under third criteria). It indicated that the social and economical development in Tianjin after 2008 was actually stable.

The social and economic conditions of Beijing and Tianjin in the 10 years had apparent progress trend. Though destruction of ecological environment was still serious, k value had tiny downtrend (1, 0.8, 0.7), thus the two regions had reached weak coordinated state after two years. The social and economic conditions in Hebei had

no apparent change in the 10 years (compared with Beijing under the evaluation criteria), the change of k value was similar to the above two regions, thus the results showed that its entire I value was uncoordinated in all 5 years.

B. ANALYSIS OF COORDINATED ABILITY

According to the division of I value coordinated section, I value in Beijing and Tianjin between 2000 and 2004 were always in uncoordinated section. Latterly they reached to weak coordination, and the index was in uptrend. The coordinated ability index in Hebei was always in uncoordinated section during the 10 years.

From time sequence, the index value of sustainable development coordinated ability in Beijing between 2006 and 2010 reached weak coordination and gradually in uptrend. Compared with that in 2000, the index value in 2010 has increased 27.86%. Compared with those between 2000 and 2004, the social, economic and environmental conditions in Beijing in 2010 all had tiny improvement. It indicated that country or region in this period of time had implemented some powerful economical macro-control measures and environmental protection policy, thus I value was always in uptrend.

I value in Tianjin between 2006 and 2010 also apparently increased. Compared with that in 2000, it had increased 8.87% in 2010. From Figure 1, we can see that I value of Beijing and Tianjin in 2008 had reached its maximum, which might be related to the influence of related policies implemented by government during Olympic Games. The selected certain one or more indexes were exactly the place that apparently improved of the region in this year.

5 Conclusion

Results showed that the overall coordinated ability in Jing-Jin-Ji region is in uncoordinated and weak coordinated section. Each region in same period of time showed up non-balance of development. It showed that

the overall ecological environmental protection ability was not simultaneously improved with social economy, which might be because the selected period (2000-2010) of researches was exactly the time that the society and economy of country and region were rapidly developed. Although under the environment of reinforcing the publicity of circular economy and energy saving and emission reduction, they were not strictly implemented for avoiding sharply lose of economic benefit.

To sum up, the application of state for measuring the damage degree of society, economic development and ecological environment has physical significance. The adoption of coordinated ability index to measure the development relationship of coordinated ability among three parts is of referential significance. The evaluation of sustainable development coordinated ability is based on fuzzy information analysis idea. The analysis process is simple and practicable, evaluation results are intuitive and understandable and of high operability. However, the different importance degree among determined indexes will affect the evaluation results, since there is certain improvement room. All in all, the evaluation of fuzzy information model in coordinated ability has certain significance to perfect of the related researches on sustainable development.

6 Acknowledgement

Hebei Project of Social Science Fund:
 “Research on the Path and Countermeasure of Hebei to Facilitate the Shift of the Strategic Emerging Industry from Beijing and Tianjin” (HB14YJ068);
 The bidding project of the collaborative innovation center of Beijing Tianjin and Hebei integration develops. Hebei University of Economics and Business
 “The research about the Capital industrial transfer and the choice and foster of strategy emerging industry in the areas around Beijing and Tianjin” (2014ZBXM05).

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