The Research on Maturity of County Economy Collaborative Development Based on Circular Economy

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Abstract: The county economy collaborative development under the guidance of circular economy theory refers to the polymerization development of the Intrinsic, holistic and comprehensive nature of county economy, to achieve the ultimate goal that a collaborative development advanced stage of a high degree of harmony within and outside the county economy. In this paper, under the guidance of the theory of circular economy, innovative proposed the maturity model of county economic collaborative development. The paper describes the index system and evaluation methods to the evaluation of county economic collaborative development, and then, supports the location of county economic collaborative development from the two dimensions of time and space. The study is conducive to support the development of county policies and to promote the sound development of county economy.

Key words: Circular economy; Industry Innovation; County economy; Industry collaborative development; Maturity model

1 Introduction

Circular economy is a new mode of production, which is the combination of economic, social, technological and environmental under the guidance of the theory of large scale systems [1] [2]. The county economy collaborative development in china refers to symbiosis between county internal harmony and the county outside. Within the county form an organic whole with mutual promotion and coordination. Then have harmonious regional economic relations with the county outside, through healthy competition and close cooperation. In order to create the best overall efficiency, the formation of the pattern of complementary advantages, the overall linkage of economic, social, technological and environmental sustainability pattern of development. Further up the ultimate goal that a collaborative development advanced stage of a high degree of harmony within and outside the county economy[3].

2 The Maturity Evaluation Index System of County Economy Collaborative Development

The evaluation of county economic collaborative development situation is a systematic project. There is not yet a complete evaluation system at home and abroad[4] [5]. We can re-definition follow ideas of multi-level hierarchical structure and circular economy. China's county economy as the socio-economic system is based on human activities for the center, and it's also na organic whole including social, economic, technological and environmental.

2.1 Hierarchical analysis of county economy collaborative development layer by layer

The county economy collaborative development is a hierarchical structure layer by layer, as shown in Figure 1.
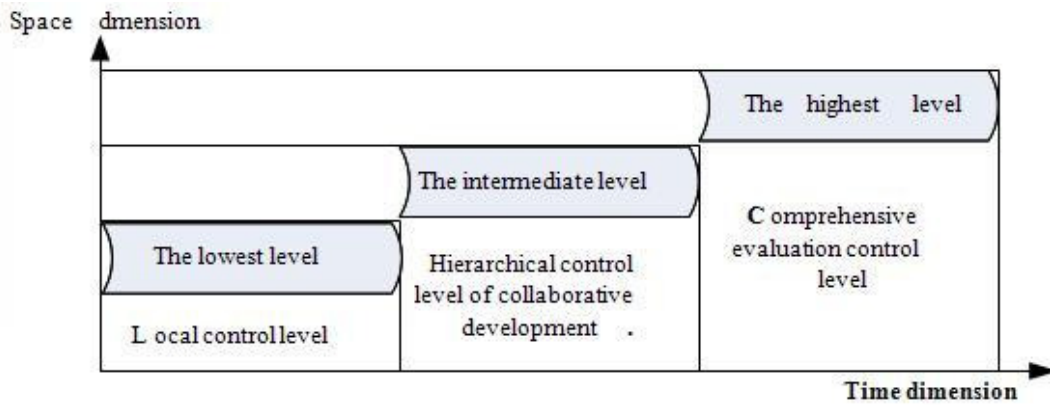
Figure 1 - Multi-level Hierarchical Structure Diagram of the County Economy Collaborative Development

(1)The lowest level is local control level of the subsystems in county economic system. The various controlled factors are the direct control of subsystems (indicators in the evaluation index system).

(2)The intermediate level is hierarchical control level of collaborative development. This level use collaborative control model to analyze the collaborative link between various subsystems. In the coordinated control of various subsystems, they also provide the optimal strategy for solutions and comprehensive data information for the most advanced coordinated development, through the most optimal means.

(3)The highest level is comprehensive evaluation control level. In this level, we establish appropriate indicators of comprehensive evaluation index and implementation plan, through the hierarchical structure and the index model of collaborative development, to achieve the county's overall goal of the industry collaborative development.

The three-level hierarchical control integrated can put forward a corresponding evaluation index system of industry collaborative development under the guidance of qualitative analysis to establish a practical methods of evaluation, and to obtain concrete results through description appropriate quantitative model description.

2.2 The system of county economy collaborative development

In recent years, China's study of collaborative development strategy between large-scale system of social economic and Subsystems in the systems, generally adopt the "Quartering" that is collaborative development among economic, technological, social and environmental. With the basic ideas that the economy is the foundation, science and technology is the driving force, the environment is the indemnification, as well as scientific, concise, systematic principles, to choose indicators match with the county economic development, we can design indicators system of china's county economy collaborative development.

(1) Social subsystem

Social subsystem including: Engel's Coefficient(X^1_1), Gini Coefficient(X^2_1), Urban per capita living space(X^3_1), Telephone penetration(X^4_1), The number of employees of business services per thousand(X^5_1), The number of doctors (number of beds) per ten thousands(X^6_1), Registered urban unemployment rate(X^7_1), Employment rate for women(X^8_1), The proportion of poverty in total population(X^9_1), Per capita premium income(X^{10}_1), The proportion of labor resources in the total population(X^{11}_1), The number of urban public theater(X^{12}_1), Per capita road area(X^{13}_1), The natural population growth rate(X^{14}_1), The urban population proportion of the total population(X^{15}_1), College educated population per ten thousands(X^{16}_1), The average life expectancy(X^{17}_1), The proportion of

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aging population in the total population(X^{18}_1).

(2) Economic subsystem

Economic subsystem including: Per capita GDP(X^1_2), GDP growth rate (X^2_2), Capital profit and tax rate(X^3_2), Value profit rate(X^4_2), On sales profit and tax rate(X^5_2), The first output value added(X^6_2), The secondary industry(X^8_2), Disposable income of urban residents(X^9_2), Per capita net income of farmers(X^{10}_2), Agricultural volume per ten thousands in agriculture(X^{11}_2), Per capita total foreign trade volume(X^{12}_2), Per capita fixed assets of industrial enterprises(X^{13}_2), Local fiscal expenditure(X^{14}_2), Passenger and freight traffic of highway and railway and aviation(X^{15}_2) and so on.

(3) Technology Subsystem

Technology subsystem including: The proportion of professional and technical personnel per thousand(X^1_3), The number of school students in general secondary schools per ten thousands(X^2_3), The number of primary school students per ten thousands(X^3_3), Per capita technology market turnover(X^4_3), Science and technology expenditures accounted in local fiscal expenditure(X^5_3), The patent approval number(X^6_3), The amount of public book per ten thousands(X^7_3), Companies invest in new product development(X^8_3), Adult literacy rate(X^9_3).

(4)Environmental subsystem

Environmental subsystem including: Per capita arable land area(X^1_4), Urban per capita green area(X^2_4), Per capita water resources(X^3_4), Per capita quantity of mineral resources(X^4_4), Per capita quantity of marine resources(X^5_4), Bio-diversity(X^6_4), Per capita quantity of plant resources(X^7_4), Per capita animal resources volume(X^8_4), Travel resource abundance(X^9_4), Natural resources utilization(X^{10}_4), Erosion rate(X^{11}_4), Tree coverage(X^{12}_4), Green energy usage(X^{13}_4), Natural disasters destroy rate of agriculture(X^{14}_4), Industrial wastewater discharge compliance rate(X^{15}_4), Industrial waste gas treatmentrate(X^{16}_4), Industrial solid waste comprehensive utilization rate(X^{17}_4), Air quality index(X^{18}_4), Water quality index(X^{19}_4), Acoustic environmental quality index(X^{20}_4), Industrial output value of energy consumption per ten thousands RMB(X^{21}_4), Industrial output power consumption per tem thousands RMB(X^{22}_4), Industrial output value of water consumption per ten thousands RMB(X^{23}_4).

3 The Construction of Maturity Evaluation Model of County Economy Collaborative Development

The indicators system of county economy collaborative development are being treated properly as a dimensionless quantity, which directly or indirectly reflect the overall performance of county economic coordinated development, through the use comprehensive theory vision of large-scale systems.

The model elements should be two: (1) The elements that reflect the coordination degree---- synergy degrees; (2) The elements that reflect the level of development----the development of capacity.

Therefore, the coordination of large-scale systems theory uses the principle of "principle of association estimates". The Collaborative variables a j i (k) of each state variable X j i (k) should be taken the actual associated variables Z j i (k) at this time. The form of ai (k) shape as:

$$a^j_i(k) = Z^j_i(k) = \sum_l a^{jl}_i X^{jl}_i(k) \qquad i=1, 2, 3, 4; \; j=1, 2, \ldots, n_i$$

After appropriate deformation, $a^j_i(k)$ can be used as collaborative degree $C^j_i(k)$. It means the total impact of $X^j_i(k)$ from other indicators of external at the k moment, which can indirectly reflect the collaborative degree (associate degree) between $X^j_i(k)$ and other indicators. When a moment the associate degree of $X^j_i(k)$ larger, then indirectly reflect the collaborative degree between $X^j_i(k)$ and j other indicators is higher; and vice versa. And after Normalization of non-dimensional indicator $Y^j_i(k)$ means the level of development of $X^j_i(k)$ at sample period (k = 1, 2, ... , N), so directly use $Y^j_i(k)$ as the development amount.

The paper use an "improved weighted additive scoring system". Use the above-mentioned collaborative degree $C^j_i(k)$ as the weight factors, the value of indicators take the above-mentioned development amount $Y^j_i(k)$. Then combine both get the basic form of collaborative development maturity index as follows:

$$D(k) = \sum_{i_j} C^j_i Y^j_i(k)$$

(1)

From the above formula we can see $D(k)$ exactly affected and identified by both at the same time. It not only can reflect the overall of collaborative degree, but also reflects the overall level of development, reached the expected requirements basically.

It is required to pre-process the collected historical data of sub-indicators, based on the establishment of the evaluation index system of county economy collaborative development. Concrete steps are as follows:

(1) Let state vector $X_i(k)$ expresses indicators included in the i (i = 1,2,3,4, corresponding to 4 subsystem as social, economic, scientific, environmental) sub-system at the time k, and

$$X^T_i(k) = \left\{ X^1_i(k), X^2_i(k), \mathbf{L}, X^{n_i}_i(k) \right\}$$

(2)

Which, n_i expresses the number of indicators of the i sub-systems.

(2) For each indicator (i = 1,2,3,4; j = 1,2, ..., n; k = 1,2, ..., N) do standardization treatment respectively, transfer into the corresponding non-dimensional indicators $U^j_i(k)$. Here using the value of standard linear equation method. That is to take the maximum and minimum values of $\{ X^j_i(k) \}$, recorded as follows:

$$\overline{X^j_i} = \max_t \{X^j_i(k)\} \qquad i=1, 2, 3, 4; j=1, 2, ..., n_i$$

$$\underline{X^j_i} = \min_t \{X^j_i(k)\} \qquad i=1, 2, 3, 4; j=1, 2, ..., n_i$$

Then $Y^j_i(k)$ can be obtained from the following formula:

$$Y^j_i(k) = \frac{X^j_i(k) - \underline{X^j_i}}{\overline{X^j_i} - \underline{X^j_i}} \qquad i=1, 2, 3, 4; j=1, 2, ..., n; k=1, 2, ..., N \quad (3)$$

(3) Take standardization for all the indicators within each subsystem $Y^j_i(k)$ by subsystem, taking

$$S^j{}_i(k) = \frac{Y^j{}_i(k)}{\sum\limits_{j=1}^{n_i} Y^j{}_i(k)} \quad i=1, 2, 3, 4; \; j=1, 2, \ldots, n; \; k=1, 2, \ldots, N \qquad (4)$$

The measuring steps of the collaborative development maturity index among the various indicators within i subsystems are as following:

(1) Adopting Delphi method, comprehensive treat relevant departments expert advice, to determine the right level of interaction between targets $a^{jl}{}_i(k)$, which express the effect that index i impact on the index in the i sub-systems within the year k. $a^{jl}{}_i(k) \neq a^{lj}{}_i(k)$, Under normal circumstances; While the i pairs of j play a catalytic role, taking $a^{jl}{}_i(k) > 0$; On the contrary, taking $a^{jl}{}_i(k) < 0$; Without effect, taking $a^{jl}{}_i(k) = 0$. In particular, indicators among themselves are $a^{jl}{}_i(k) = 1$. $a_i(k)$ is the actual situation, corresponding values obtained according to the level of impact.

(2) Calculating the total impact $b^j{}_i(k)$ on the index j from other indicators i ($l \neq j$).

$$b^j{}_i(k) = \sum\limits_{\substack{j=1 \\ l \neq j}}^{n_i} a^{jl}{}_i S^l{}_i(k), i = 1,2,3,4; \; j = 1,2,\cdots,n; k = 1,2,\cdots,N \qquad (5)$$

Here, only consider other indicators of the impact on index j, and ignore its own impact.

(3) Calculating the impact results that other indicators of the impact on index j, that is collaborative degree $C^j{}_i(k)$.

$$C^j{}_i(k) = \frac{b^j{}_i(k)}{\sum\limits_{l=1}^{n_i} b^l{}_i(k)} \qquad (6)$$

(4) Calculating Maturity index of collaborative development within subsystems $D_i(k)$.

$$D_i(k) = \sum\limits_{j=1}^{n_i} C^j{}_i(k)Y^j{}_i(k), i = 1,2,3,4 \qquad (7)$$

The measuring steps of the collaborative development maturity index among the various indicators among each subsystem in the large systems are as following:

(1) Adopting Delphi method, comprehensive treat relevant departments expert advice, to determine the right level of interaction between targets $a^{jl}{}_{ip}(k)$, which express the effect that index l in sub system p impact on the index j in the i subsystem within the year k. Its value is the same as (1).

(2) Calculating the total impact $b^j{}_i(k)$ on the index j from i index of other subsystems.

$$b^j{}_i(k) = \sum\limits_{\substack{p=1 \\ p \neq j}}^{m-1} \sum\limits_{l=1}^{n_p} a^{jl}{}_{ip} S^l{}_p(k), i = 1,2,3,4; \; j = 1,2,\cdots,n; k = 1,2,\cdots,N \qquad (8)$$

Here, only consider other subsystem indicators of the impact on index j, and ignore its own system impact. M is number of subsystems that the discussed large-scale systems have, here m = 4.

(3) Calculating the impact results that other subsystem indicators of the impact on index j, that is collaborative degree $C^j{}_i(k)$.

$$C^j{}_i(k) = \frac{b^j{}_i(k)}{\displaystyle\sum_{p=1}^{m}\sum_{l=1}^{n_p} b^l{}_p(k)}, i = 1,2,3,4; j = 1,2,\cdots,n_i; k = 1,2,\cdots,N \qquad (9)$$

(4) Calculating Maturity index of collaborative development of the whole large-scale system $D(k)$.

$$D_i(k) = \sum_{i=1}^{m}\sum_{j=1}^{n_i} C^j{}_i(k) Y^j{}_i(k) \qquad (10)$$

4 The Evaluation of China's County Economy Collaborative Development Maturity

In this study, we have selected 2056 counties from 31 provinces, municipalities and autonomous regions (excluding Hong Kong, Macao and Taiwan) all over the country, and evaluated collaborative development maturity of year 2006, 2007 and 2008. In order to grasp the national macro-economic situation of collaborative development in the county, using cluster analysis methods to classify. The results showed that the maturity of industry collaborative development in eastern part is superior to central and western significantly.

In 2006 the industry collaborative development maturity of the counties located in the former three categories were 253, the eastern region are 219, mainly in the Yangtze River Delta, Pearl River Delta and the Bohai Economic Circle, of which 37 in Zhejiang Province, 70 in Shandong Province, 39 in Jiangsu Province, 11 in Fujian Province, 26 in Guangdong Province, 28 in Hebei Province, 5 in Beijing, 3 in Tianjin, and 3 in Shanghai.

In 2007 the industry collaborative development maturity of the counties located in the former three categories were 251, the eastern region are 196, mainly in the Yangtze River Delta, Pearl River Delta and the Bohai Economic Circle, of which 39 in Zhejiang Province, 44 in Shandong Province, 38 in Jiangsu Province, 11 in Fujian Province, 24 in Guangdong Province, 27 in Hebei Province, 5 in Beijing, 5 in Tianjin, and 3 in Shanghai.

In 2008 the industry collaborative development maturity of the counties located in the former three categories were 238, the eastern region are 211, mainly in the Yangtze River Delta, Pearl River Delta and the Bohai Economic Circle, of which 37 in Zhejiang Province, 40 in Shandong Province, 35 in Jiangsu Province, 12 in Fujian Province, 17 in Guangdong Province, 32 in Hebei Province, 2 in Beijing, 4 in Tianjin, and 3 in Shanghai.

At the same time, the data shows a good momentum of economic development, collaborative development of the county tend to have a higher maturity. So, we use the selected hundred of China's economic development from Central County Economic Research Institute as a county study. Hundred counties in the county nearly 90 percent located the sorting out the first hundred of county economy collaborative development maturity of the county. We will China's economic development hundred counties in 2006 - 2008 joint development of the maturity to sort with the County Economic Research Institute of the county to make a comprehensive index of sort for Friedman test results obtained as shown in Table 1 and Table 2.

In the table 68.6% of the high probability shows that the county economy collaborative development maturity is an important characterization of the county's economic development factor. The evaluation of county economy collaborative development maturity based on circular economy theory can better position the county's economic development level, can able to clear to the development potential of China's county-level better, what's more, can express the overall layout of the development of China's county-level and condition from the perspective of the global, reflects the collaborative development of China's county economy over the gradient.

	Mean Rank
The sort of collaborative development maturity	1.52
The sort of hundred counties comprehensive index	1.48

Tabela 2 – Friedman Test Statistics

N	100
Chi-Square	.163
Df	1
Asymp. Sig.	.686

The use of the county economy collaborative development maturity model based on circular economy, not only can help the county cycle formulate appropriate economic measures according to its own specific development, and can give the evaluation of the preliminary work to correct deviations in the process of development; but also conducive to country adapt the principle of complementary advantages, plan overall layout and plan of china's county circular economy development, under the specific circumstances of county collaborative development.

5 Conclusions

To establish a social support system that conducive to the development of circular economy, and to provide a good overall atmosphere for the development of circular economy from the institutional, technical and ideas. All of this can able to promote economic and social development into the track of a virtuous cycle, what's more, it is the fundamental principles for the future development of county economy.

The social development level, three industrial structures, leading industry positioning and layout of china's county economy are quite different industries, so the development of circular economy should also be focus different. The paper proposed the evaluation of county economy collaborative development maturity model can not only measure the level of county collaborative development as a whole, but also illustrated the degree of development separately from the four major subsystems in the social, economic, technological and environmental collaboration. Using the model, we can see the advantages and inadequacies of a particular county development, which would help to develop appropriate improve measures; at the same time, it conducive to country adapt the principle of complementary advantages, plan overall layout and plan of china's county circular economy development, under the specific circumstances of county collaborative development.

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