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The Research of Regional Industry Linkage in Zaozhuang Based on Complexity Theory and Grey Relational Degree

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Abstract: In order to achieve association of carrier industry such as the flow, logistics, capital flow, information flow and improve the connection of infrastructure of two transportation network and communication information network, a new method of evaluating the industry linkage degree based on complexity theory and grey relational degree is provided in this study. The study uses the formula method and gray correlation method to establish Zaozhuang industrial linkage development model, quantitatively analyses the seven major economic development zones in Zaozhuang. Then, we give development proposals of industrial linkage of Zaozhuang according to the analysis result. The recommend has certain reference value in critical stage of industry transformation industries and linkage in Zaozhuang.

Keywords: Formula, grey relational, industry linkage, zaozhuang

INTRODUCTION

Industry linkage is an interconnectedness and interaction between economic organizations with similar characteristics and same attributes. These organizations are combined to an economic cooperation or an economic bloc on common or similar institutional framework or regulatory mechanism, while its aim is to achieve complementary advantages and coordinated development between regional economic and industry and then optimize of regional industrial structure and upgrade the industry level and enhance regional economic and industrial competitiveness. Achieve industry coordination on the same or different level of the industry chain based on industry linkages. It is based on the area between the "administrative" as the basic unit for the main market-oriented, so it needs the administrative force to promote the industry and fully consider each other's needs and mutual benefit and form a benign Development of two-way interaction system, in order to achieve association of carrier industry such as the flow, logistics, capital flow, information flow and achieve the connection of infrastructure of two transportation network and communication information network.

Many scholars have studied the region linkage development in recent ages and achieve many good results. Bingqing *et al*. (2009) have the researches on the potentiality of regional economic cooperation with the analysis of industrial linkage and take it into use in the huaihai economic zone, which obtain a good analysis result. Tao and Rui (2006) have the theoretical analysis to the industry linkage and then discuss the manifestation, which has a good guidance to the actual industry. Liping (2009) have the analysis to the development mode of country economy in the situation of industrial linkage and achieved fulfilled research results.

As an efficient and multi-win behavior, regional industrial linkage is able to make full use of resources and improve the efficiency of economic development. In recent years, it has become the main direction of the current regional economic development. As a typical resource-dependent city, Zaozhuang gives full play to its advantages in resources as well as good industrial base, makes industry linkage as the way to revive the economy. This study makes quantitative analysis of Industrial Linkage in Development Zone of Zaozhuang by formula method and gray correlation method and proposed of industrial linkage development strategy for Zaozhuang, so as to have the analysis to the complexity of regional industry linkage of Zaozhuang and obtain the main factors which can impact the linkage most with the method of grey relational degree. The conclusion of this study has a good guidance to the region linkage development.

THE EVALUATION OF INDUSTRY LINKAGE DEGREE IN PROVINCIAL PARKS IN ZAOZHUANG BY FORMULA METHOD

Industry linkage potential function among parks is given by:

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$$C_{ij} = n - \sum_{k=1}^{n} \left(\frac{2 * x_{ik} * x_{jk}}{x_{ik}^{2} + x_{jk}^{2}} \right)$$

where,

I & j : The symbol representing the two parks

x_{ik} & x_{jk} : The proportion of the industrial k in the region i and regions j

n : The number of industries both in the park i and park

j & C_{ij} : Industry linkage potential between park I and park j

which is determined by two parts: one part is the number of co-development industry, the more number of co-development industry, the greater potential of industry linkage. The other part is the different development situation of the same industry in two parks, the closer proportion in different parks, the smaller different degree.

The data is given by Zaozhuang Statistics Yearbook (2011). Based the following formula, we can calculate industrial linkage potential in all the parks, as shown in the Table 1.

From the Table 1, we can see the largest industrial linkage potential in parks is the one between Tengzhou Economic Development Zone and Zaozhuang Economic Development Zone, the industrial linkage potential is 8.7226, which is far more than the potential in other parks. One reason is that the large proportion differences between industry, another important reason is that these two parks are both relatively large size park, the number of co-development industry is very much and almost all industries have been covered. The industrial linkage potential between Xuecheng Economic Development Zone and Taierzhuang Economic Development Zone, the industrial linkage potential among Zaozhuang High-tech Zone, sanjong Economic Development Zone and Zaozhuang High-tech Zone, The industrial linkage potential between Taierzhuang Economic Development Zone and Zaozhuang High-tech Zone, are small, their value is less than 1, one reason is the similar proportion of two park industry, another more important reason is the number of industries in these parks are relatively small and the number of co-development industry is few more.

To the Industry linkage potential among one single park and all other parks, Tengzhou economic development zone and Zaozhuang Economic Development Zone is the largest, the numbers are 23.6202 and 23.4546, which is in accord with larger size and rich industrial composition of the two parks. And Industrial Linkage potential of Xuecheng Economic Development Zone, the Taierzhuang Economic Development Zone and Zaozhuang High-tech Zone is small, the numbers are 9.2205, 9.679 and 9.8481 and the GDP of the three park area is also smaller than the other seven parks, this industry linkage potential situation is in accord with the single industrial structure, the relatively underdeveloped state of the economy and the relatively small size of the economy of the three parks.

Table 1: Industrial linkage potential in all the parks

Linkage potential c_{ij}	Tengzhou economic development zone (Num. 1)	Zaozhuang economic development zone (Num. 2)	Xuecheng economic development zone (Num. 3)	Shangting economic development zone (Num. 4)	Yicheng economic development zone (Num. 5)	Tai'erzhuang economic development zone (Num. 6)	Zaozhuang high-tech zones (Num. 7)
Tengzhou economic development zone (Num. 1)	-	8.7226	2.0936	2.9869	4.4203	3.2232	2.1736
Zaozhuang economic development zone (Num. 2)	8.7226	-	2.6110	3.5426	2.9082	2.3149	3.3553
Xuecheng economic development zone (Num. 3)	2.0936	2.6110	-	1.3439	1.9810	0.5084	0.6826
Shangting economic development zone (Num. 4)	2.9869	3.5426	1.3439	-	2.3789	1.0399	0.9620
Yicheng economic development zone (Num. 5)	4.4203	2.9082	1.9810	2.3789	-	1.8692	1.9512
Tai'erzhuang economic development zone (Num. 6)	3.2232	2.3149	0.5084	1.0399	1.8692	-	0.7234
Zaozhuang high-tech zones (Num. 7)	2.1736	3.3553	0.6826	0.9620	1.9512	0.7234	-
Total	23.6202	23.4546	9.2205	12.2542	15.5088	9.6790	9.8481

EVALUATION ANALYSIS OF PARK INDUSTRY RELATED DEGREE BY GRAY CORRELATION METHOD

Model of the gray correlation method:

Evaluation matrix: We suppose that the number of evaluation objects which will be measured in the system is n and each object has m factors need to be evaluated, each evaluation object attribute matrix with the respective evaluation factors are as follows:

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & \cdots & x_{2n} \\ \vdots & \vdots & x_{ij} & \cdots & \cdots \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & \cdots & x_{mn} \end{bmatrix}, \quad (1)$$

where, i = 1, 2, …, m, j = 1, 2, …, n

x_{ij} in the formula (1) represents the evaluation attribute value of the object j under evaluation factors i. what we should pay attention to is that, in the formula (1), the evaluation requires the establishment of a reference sequence and evaluation sequence. The reference sequence is set x_i (0), where i = 1, 2,…, m; evaluation sequence is set x_i (j), where i = 1, 2,…, m, j = 1, 2,…, n.

Standard processing of normalization data: The attribute matrix x = $(x_{ij})_{m\times n}$ of the system normalized standard treatment, we get the new attribute matrix y = $(y_{ij})_{m\times n}$ after normalization, where $0\leq y_{ij}\leq 1$.

In this case, we establish the normalized formula:

$$y_{ij} = \frac{x_{ij} - \min\limits_{j} x_{ij}}{\max\limits_{j} x_{ij} - \min\limits_{j} x_{ij}}, where,\ \ i = 1,2,\cdots,m;\ j = 1,2,\cdots,n \quad (2)$$

The greater indicators value of y_{ij}, the higher association of evaluation object.

To ensure negative value appears in the matrix after the standard processing of evaluation sequence normalized, the absolute value processes to it:

$$\Delta_{ij} = |y_i(0) - y_i(j)|, where, i = 1, 2, \ldots, m;\ \text{j} = 1, 2,\ldots, \text{n} \quad (3)$$

According to the above formula (3), we can obtained for each i of the maximum value Δ_{max}(i) and the minimum value Δ_{min}(i), its value is given by:

$$\Delta_{\max}(i) = \max_{j} |y_i(0) - y_i(j)|$$

$$\Delta_{\min}(i) = \min_{j} |y_i(0) - y_i(j)|$$

$$i = 1,2,\cdots,m;\ j = 1,2,\cdots,n$$

Gray related degree of one indicator: Set λ_{ij} is the gray correlation degree of evaluation factors y_i(j) of reference values y_0(j), its calculation formula is defined as:

$$\lambda_{ij} = \frac{\Delta_{\min}(i) + \theta\Delta_{\max}(i)}{\Delta_{ij} + \theta\Delta_{\max}(i)} \quad (4)$$

In Eq. (4), θ is a scaling factor, where 0≤θ≤1. Generally, take θ = 0.5.

The calculations of entropy and entropy weight: When we calculate and evaluate the different objects of different indicators, we often need to assess the relative importance of the various indicators and then give weight to it. Entropy weight is actually the weight of different factors. In this model, the entropy weight calculation steps are as follows:

- To the evaluation object J, Calculated for the proportion ρ_{ij} of the property value y_{ij} of the factor i:

$$\rho_{ij} = \frac{y_{ij}}{\sum\limits_{i=1}^{m} y_{ij}},\ j = 1,2,\cdots,n \quad (5)$$

- Calculate information entropy ξ_j of the evaluation object j:

$$\xi_j = -c\sum_{i=1}^{m} (\rho_{ij} \ln \rho_{ij}) \quad (6)$$

where, c is a constant, its value is c = $\frac{1}{1n\,m}$, and $0\leq\xi_j\leq 1$.

- Calculating the difference coefficient δ_j and the weighting coefficient w_j of the j-th evaluation object:

$$\delta_j = 1 - \xi_j$$

$$w_j = \delta_j / \sum_{j=1}^{n} \delta_j \quad (7)$$

Calculate gray correlation degree based on entropy weight: Here, set of gray correlation degree r_j between different evaluation object, the formula is:

$$r_j = w_j / \sum_{i=1}^{m} \lambda_{ij} \quad (8)$$

The evaluation of the gray relational degree in industrial park: To select seven industry as evaluation object: food manufacturing industry, textile industry,

Table 2: The evaluation of the gray relational degree in industrial park

Sales revenue in the parks	Tengzhou	Zaozhuang	Xuecheng	Shanting	Yicheng	Taierzhuang	Zaozhuang hi-tec
Food manufacturing industry	45.18	2.15	13.16	25.87	1.35	0	4.36
Textile industry	27.82	8.66	0	0	10.38	10.16	0
Textile and garment, shoes, hat manufacturing	6.83	53.99	13.35	3.10	9.56	17.98	3.60
Paper and paper products industry	16.09	2.69	15.94	12.93	0.92	11.01	0
Chemical materials and chemical products manufacturing	75.95	47.91	13.53	2	8.23	4.50	5.40
Electrical machinery and equipment manufacturing industry	35.47	32.79	38.93	15.60	16.56	26.02	0
Communications, computers and other electronic equipment manufacturing	9.42	0.31	0	0	5.26	0	28

textile, manufacturing, paper and paper products industry, chemical raw materials and chemical products manufacturing, electrical machinery and equipment manufacturing, communications, computer and other electronic equipment manufacturing. Regard these seven industries as the seven object needs to be evaluated and regard the seven industry's sales revenue in seven parks as the evaluation factors for each evaluation object.

After data collation, we get the following Table 2.

Substitute the data in the table into the above model and calculate. We have to establish a reference sequence $x_i(0)$, i = 1, 2, …, 7 first, in order to measure for industry related degree. As the fact that the bigger value of the attribute, the greater degree of correlation, we set $x_i(0) = max_j\ x_{ij}$, j = 1, 2, …, 7:

$$x_i(0) = \begin{bmatrix} 75\ .95 \\ 53\ .99 \\ 38\ .93 \\ 25\ .87 \\ 16\ .56 \\ 26\ .02 \\ 28 \end{bmatrix}$$

The evaluation sequence is x_i, (j), j = 1, 2, …, 7. Where x_i, (j) = x_{ij}; i = 1, 2, …, 7; j = 1, 2, .., 7.

Finally, to calculate differential coefficient m and weight coefficient n of the j-th evaluation objects (industrial), its numerical vector is as follows:

$$\delta_j = [0.3246\ \ 0.3401\ \ 0.1984\ \ 0.2833\ \ 0.1419\ \ 0.105\ \ 0.6722]$$

$$w_j = [0.1572\ \ 0.1647\ \ 0.096\ \ 0.1372\ \ 0.0687\ \ 0.0508\ \ 0.3254]$$

Industrial gray relational grade based on entropy weight: Substitute the weights m and gray correlation degree of individual indicators n into the formula of gray correlation degree q of evaluation object (industry), we can get gray correlation degree vector for each industry as follows:

$$r_j = [0.5257\ \ 0.461\ \ 0.3494\ \ 0.3839\ \ 0.264\ \ 0.2495\ \ 1.0037]$$

Therefore, by the above calculation, we can get gray correlation degree of the seven industrial, respectively, for the food manufacturing industry 0.5257, the textile industry 0.461, textile and manufacturing 0.3494, paper and paper products industry 0.3839, chemical materials and chemical products manufacturing 0.264, electrical machinery and equipment manufacturing industry 0.2495, communications, computers and other electronic equipment manufacturing 1.0037.

Which, gray correlation of communications, computers and other electronic equipment manufacturing is the highest. One reason is that, the number of the industrial park which develop this industry is less, only four, the potential of developing the industry in the other park is huge; the other reason is that the development of regional industry is relatively concentrated, mainly in Zaozhuang High-tech Zone, the park's sales revenue ($ 2.8 billion) is much larger than the total sales revenue (14.99 billion) of the other parks, the two reasons cause the industry has a very large gray relational degree and a great interaction potential in the parks. It's a good industry direction of interaction development of regional industry, can be a development focus in the future.

On the other hand, electrical machinery and equipment manufacturing industry has the minimal industrial gray relational degree, only 0.2495, the reason is similar to communications computers and other electronic equipment manufacturing industry, but its situation is just the opposite. On one hand, the number of the development of the industrial park is big, only Zaozhuang High-tech Zone does not regard these industries as the most important one, which largely reduces its development potential in the future; on the other hand, development regional of this industry is disperse, sales income gap between the various park is small, making the industry development between the various park more balanced, hard to form the economy "potential difference" of industrial development, which makes the difficulty of the industrial area linkage enhancements.

PROPOSALS OF ZAOZHUANG INDUSTRIAL LINKAGE DEVELOPMENT

Give full play to the comparative advantage of economies park: Regional industrial linkage is to

reduce the vicious competition between the different regional economic Park, eliminate inefficient behavior "fragmentation" between different administrative units, to play the economic development of the whole "synergies" and "economies of scale" to improve the entire Zaozhuang economic competitiveness. Therefore, the regional industry linkage must be based on the comparative advantage of the area within the park, keep a long-term vision as well as the overall situation, to avoid a vicious competition due to the short-sighted behavior.

Promote the construction of market integration: Regional industrial linkage should be basis of market linkage, the market competition has led to the division of labor between the behavior of the produce, is the fundamental driving force for the development of regional industrial linkage. The market is the guarantee of economic efficiency and an important prerequisite for the optimal use of resources, therefore we should fully take advantage of the market and promote the rational flow of resources basing on static advantages of the region. Market integration, on the one hand can ensure the reasonableness of the structure of the production factors and demand supply, on the other hand can optimize the industrial structure, promoting the upgrade and coordinated development of regional industrial structure.

Respect for the dominant position of enterprises in the regional industrial linkage: During the regional industrial linkage process, we must insist on the linkage principal position, it is not only the main part of the integration and the rational use of resources, but also the main part of the cooperation and competition in industrial linkage, they are driven by the market and profit-driven motives, seek the most beneficial form of regional cooperation organization to achieve efficient allocation of resources. In this process, the Government must not "overwhelming", but give support and conditions to enterprises, bear in mind that the enterprise is the business development center.

Therefore, in the development of regional industrial linkage, you must do the following:

- **Thoroughly understand:** Regional industry should be sublimated linkage to the height of the strategy to get to know, to find a breakthrough in economic structure optimization.
- **The government should guide:** To keep in mind that in the economic development the government will never be bystanders. The government should promote the integration, in order to realize cross-industry, cross-department, cross-regional, cross-ownership, to build a good environment for regional industrial linkage.
- **Leading technology:** The current economic development is the development of high-tech economy, only by holding the leading technology, can the enterprise maintain a competitive advantage to occupy the dominant position in the fierce competition in the market.
- **The strong core enterprise:** In the process of regional industrial linkage, the core enterprise is the key to development, it is the main part of industry linkage and integration and plays a driven and innovation role. Especially some large listed companies, which are precious resource in the linkage of the regional industry, have to be effectively used.
- **Finance convenient:** There will be a large number of enterprises expansion, mergers and restructure in the development of regional industrial linkage, smooth financing channels must be provided in this process.

CONCLUSION

The study uses the formula method and gray correlation method to establish Zaozhuang industrial linkage development model, quantitatively analyses the seven major economic development zones in Zaozhuang. Then, we give development proposals of industrial linkage of Zaozhuang according to the analysis result. The recommend has certain reference value in critical stage of industry transformation industries and linkage in Zaozhuang.

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