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Gray Correlation Degree Between the Industrial Structure Adjustment of Agriculture and the Agricultural Economic Development

—A Case of Heilongjiang Province, China

LIU Nan*

Department of Economics and Management, Daqing Normal University, Daqing 163712, China

Abstract Calculation method of gray correlation degree and the connotation of gray correlation are introduced. Based on the model of gray correlation degree, relationship between agricultural industrial structure and agricultural economic development is analyzed by using four analysis methods of correlation degree and according to the relevant data in the years 2002–2008. The calculation results of four types of gray correlation degree are compared. Research shows that combination of the linear weighted gray correlation degree and Deng's gray correlation degree is more appropriate. Development of animal husbandry has the highest correlation degree with the development of agricultural economy. Meat yield production has higher correlation degree with agricultural economic development than other industries, while the correlation degree between agriculture and primary industry is the lowest. Based on this, related countermeasures are put forward in order to promote the agricultural economic development of Heilongjiang Province. Firstly, develop animal husbandry and agricultural processing industry. Secondly, promote the internal restructuring of agriculture. Thirdly, find out the industry that should be given priority in different areas according to the regional characteristics and market demand. Fourthly, improve the related industrial development system.

Key words Agricultural industrial structure, Gray correlation degree, Dimensionless, Evaluation, China

Adjustment of agricultural structure is essentially the adjustment of proportion relation among agricultural industries and varieties production. At present, adjustment of agricultural structure in China is mainly manifested in the change of agricultural interior structure from planting industry to the joint development of planting industry, forestry, animal husbandry, and fishery. Structure of planting industry has also changed from mainly the grain to the comprehensive and concerted development of grain crops, cash crops and feed crops. Animal husbandry pays attention to the overall development of meat, egg and milk. Changes in agricultural structure will inevitably stimulate the economic development of agriculture and enhance the income level of peasants. Taking Heilongjiang Province as an example, gray correlation degree is used to analyze the relationship between the industrial structure adjustment of agriculture and the agricultural economic development. And the calculation results of different gray correlation degrees are compared in order to optimize the agricultural industry structure and to offer references for the development of agricultural economic development.

1 Research method, index selection and data source

1.1 Research method Gray correlation denotes correlation of uncertainty among things, system factors, or the uncertainty

of factors for main behavior. Gray relational analysis is a measurement method that analyzes the correlation among discrete sequences in gray system theory. Gray basic idea is to determine the degree of correlation among factors according to the similarity among curves.

1.1.1 Dimensionless treatment of data. X is the factor set of gray correlation, $X_0 \in X$ is reference sequence, $X_i \in X$ is comparison sequence, $X_0(k)$ and $X_i(k)$ ($k=1, 2, 3, \dots, m$) are the numbers of X_0 and X_i ($i=1, 2, 3, \dots, n$) at point K , which can construct the original evaluation matrix $X = (X_0, X_1, X_2, \dots, X_n)$.

Since the data units of reference sequence and comparison sequence are different, dimensionless treatment on original sequence needs to be carried out. The commonly used methods are initialization method, equalization method, and interval value method. And this research uses initialization method. The equation is

$$x'_i(k) = \frac{x_i(k)}{x_i(1)}, \quad (1)$$

where $k=1, 2, \dots, m$ and $i=1, 2, \dots, n$.

After dimensionless treatment, matrix after treatment is obtained as a further basis for calculating.

1.1.2 Calculation of gray relation coefficient. Firstly, calculate the absolute value of corresponding element in reference sequence and comparison sequence, that is, $|x'_0(k) - x'_i(k)|$. Then, correlation coefficients of corresponding elements in reference sequence and comparison sequence are calculated, its equation is

$$\zeta'_i(k) = \frac{\min_{i,j} |x'_0(k) - x'_i(k)| + \rho \max_{i,j} |x'_0(k) - x'_i(k)|}{|x'_0(k) - x'_i(k)| + \rho \max_{i,j} |x'_0(k) - x'_i(k)|}, \quad (2)$$

where ρ is resolution coefficient, with its value ranging from 0 and 1. The smaller the ρ is, the greater the difference between correlation coefficients becomes, and *vice versa*. Usually, $\rho = 0.5$.

1.1.3 Calculation of correlation degree. Assuming that different elements have different weights in vectors, weight vector is

$$\omega_i = (\omega_{1i}, \omega_{2i}, \dots, \omega_{ki}).$$

Hence, we have

$$H_1 = \gamma_{0i} = \sum_{k=1}^m \omega_{ki} \zeta'_{0i}(k), \quad (3)$$

where H_2 is the linear weighted gray correlation^[1].

If ω_{ki} is equal weight, we have

$$H_2 = \gamma_{0i} = \frac{1}{m} \sum_{k=1}^m \zeta'_{0i}(k), \quad (4)$$

$$H_3 = \gamma_{0i}' = 1 - \frac{1}{m} \left[\sum_{k=1}^m (1 - \zeta'_{0i}(k))^2 \right]^{\frac{1}{2}}, \quad (5)$$

where H_2 is Deng's gray correlation^[2], and H_3 is the Gray Euclid Relation Grade.

If ω_{ki} is non-equal weight, we have

$$H_4 = \gamma_{0i} = 1 - \left[\sum_{k=1}^m \omega_{ki}^2 (1 - \zeta'_{0i}(k))^2 \right]^{\frac{1}{2}}, \quad (6)$$

Table 1 Original value of index sequence in Heilongjiang Province from the year 2002 to 2008

Year	$X_0 // \times 10^8$ yuna	$X_1 // \times 10^4$ t	$X_2 // \times 10^4$ t	$X_3 // \times 10^4$ t	$X_4 // \times 10^4$ t	$X_5 // \times 10^4$ t	$X_6 // \times 10^4$ hm ²
2002	447.0	2 941.2	190.0	84.6	236.0	41.8	96.80
2003	513.0	2 512.3	217.2	90.3	303.9	42.0	120.87
2004	587.8	3 135.0	260.5	98.3	378.1	43.0	158.67
2005	672.5	3 600.0	306.3	102.7	444.2	44.5	232.67
2006	734.0	3 780.0	319.6	107.6	464.6	46.5	276.67
2007	892.5	3 965.3	335.3	108.3	511.7	48.8	312.00
2008	1 089.1	4 225.0	303.3	109.3	581.5	35.6	344.67

Table 2 Comparison of calculation values of gray correlation

Gray correlation	γ_{01}	γ_{02}	γ_{03}	γ_{04}	γ_{05}	γ_{06}
H_1	0.685 2	0.975 2	0.825 4	0.738 6	0.798 7	0.592 4
H_2	0.612 9	0.794 0	0.673 4	0.581 1	0.663 8	0.562 8
H_3	0.836 3	0.886 2	0.851 5	0.817 4	0.851 0	0.808 4
H_4	0.827 9	0.868 6	0.838 4	0.844 6	0.834 4	0.836 6

Note: $\gamma_{01} - \gamma_{06}$ are gray correlation degrees of the added values of primary industry, the same as follows.

2 Result and analysis

2.1 Calculation of gray correlation Firstly, use initialization method to conduct dimensionless processing on data. Secondly, calculate gray correlation coefficient by equation (2). Thirdly, calculate the gray correlation according to equations (3) – (6). Finally, comprehensive sequencing and evaluation are carried out (Table 3).

Table 3 Sequence of evaluation results

Gray correlation	γ_{01}	γ_{02}	γ_{03}	γ_{04}	γ_{05}	γ_{06}
H_1	5	1	2	4	3	6
H_2	4	1	2	5	3	6
H_3	4	1	2	5	3	6
H_4	6	1	3	2	5	4

where H_4 is the Gray Euclid Relation Grade^[1].

1.1.4 Comprehensive evaluation. According to equations (3) – (6), comprehensive correlation degree of reference sequence and comparison sequence is obtained. The greater the correlation degree is, the bigger the numerical value becomes, and *vice versa*.

1.2 Index selection The goal of agricultural development in Heilongjiang Province is to change from major agricultural province to strong agricultural province. Adjustment of agricultural industrial structure in Heilongjiang Province is to maintain the steady growth of main crop yield, to vigorously develop animal husbandry, and to increase the planting area and intensity of green products. Therefore, to analyze the relationship between the agricultural industrial structure adjustment and the agricultural economic development, added value of primary industry (X_0) is selected in reference sequence; and comparison sequence chooses the total grain yield (X_1), meat output (X_2), egg output (X_3), milk output (X_4), output of aquatic products (X_5) and planting area of green foods (X_6).

1.3 Data source Data in this research are from the 2002 – 2008 Heilongjiang Statistical Bulletin (Table 1).

2.2 Result analysis

(1) Table 2 reports that among the 4 calculation methods of correlation degree, Deng's gray correlation degree and linear weighted gray correlation degree have significant differences of the correlation degrees calculated. There are relatively small differences among correlation degrees calculated by Gray Euclid Relation Grade and Gray Weighted Euclid Relation Grade. Table 3 reports that the correlation orders are close to each other by the three methods, including the Gray Euclid Relation Grade, the Deng's Correlation Degree, and the linear weighted gray correlation degree. The former three and the last one have the same rank. At the same time, calculation results of Deng's Correlation Degree and Gray Euclid Relation Grade have the same rank; while the rank of calculation result of Gray Weighted Euclid Relation Grade is different from the former three methods. Further observation of Table 2 reports that numerical results of orders 2 – 6 are very similar. According to the relationship, sorting and evaluation of agricultural industrial adjustment and agricultural economic development, Deng's Gray Correlation Degree and linear weighted gray correlation degree are more suitable for calculation and analysis.

(2) Based on the above analysis, correlation degree between the development of animal husbandry and the development of agricultural economy is the maximum (γ_{02} and γ_{03} take

the first and the second places, respectively; and meat output has higher correlation degree with the development of agricultural economy than other industries). And correlation degree between agriculture and primary industry is the minimum (γ_{01} and γ_{06} take the fifth and sixth places, respectively). This is mainly because that based on the idea and direction of modern agricultural development and relying on the natural resources and traditional advantages, China has vigorously promoted the development of animal husbandry, has increased the output of meat, egg and milk, and has achieved rapid development of primary industry under the premise of maintaining agricultural development. Thus, primary industry has achieved rapid development. In the long run, crop-based agriculture will on the whole remain a stable and slow growth; while animal husbandry will achieve rapid development. Both the proportion of animal husbandry in primary industry and the correlation degree between animal husbandry and primary industry will increase, as well as the contribution rate of animal husbandry to farmers' income increase. Therefore, development of animal husbandry is the only way for Heilongjiang Province to change from big agricultural province to strong agricultural province.

3 Discussion

(1) Combined with empirical results, adjustment of agricultural structure in Heilongjiang Province should pay attention to the following four aspects. Firstly, continue to develop animal husbandry and agricultural product processing industry; highlight the geographical and industrial advantages; pay attention to the refinement during the development of animal husbandry; and greatly develop milk and meat processing industry by relying on leading enterprises. Secondly, enhance the structural adjustment of agriculture; maintain the existing "two high and two low" of food production; adjust the ratios of grain crop, cash crop and forage crop to make them more rational; enlarge the planting area of green products and high-quality agricultural products; strengthen scientific and technological innovation; and actively improve existing varieties and develop new varieties in order to meet the demand of market. Thirdly, based on the principles of promoting the development of county economy and increasing the agricultural income, industries with priority development in different areas are selected scientifically and rationally according to the regional characteristics and market demand.

Starting from the perspective of large scale, industrialization and clustering, all-round service and support of agricultural industry chain is carried out. Fourthly, improve the development system of related industry and ensure and support the development of agricultural industrial development.

(2) Analysis shows that Deng's Gray Correlation Degree and linear weighted gray correlation degree are more suitable for the analysis on the relationship between industrial development and industrial restructuring, so as to provide references for the future industrial development. In the future research, we should pay attention to the following three aspects. Firstly, carry out comprehensive analysis, comparison and evaluation of gray correlation degree; find out a method suitable for the analysis of agricultural structure optimization. Secondly, refine the research on agricultural industrial structure; expand the research area and conduct horizontal comparison. Thirdly, introduce qualitative factors into research and combine the qualitative and quantitative researches together, in order to make research results more realistic, practical and operational.

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农业产业结构调整与农业经济发展的灰色关联度分析——以黑龙江省为例

刘楠 (大庆师范学院经济管理系, 黑龙江大庆 163712)

摘要 介绍了灰色关联的内涵及灰色关联度的计算方法。基于灰色关联度模型,利用线性加权灰色关联度、邓氏灰色关联度、灰色欧几里德关联度、灰色加权欧几里德关联度4种关联度分析方法,根据2002~2008年相关数据,实证分析了黑龙江省农业产业结构与农业经济发展之间的关系,并比较了4种灰色关联度计算结果。研究表明,利用邓氏灰色关联度和线性加权灰色关联度的方法进行计算和分析更为适合;畜牧业的发展与农业经济发展之间的关联度是最高的,其中,肉产量与农业经济发展的关联度大大高于其他行业;而农业与第一产业的关联度是最低的。基于此,提出了推进黑龙江省农业经济发展的相关对策建议:一是发展畜牧业和农产品加工业;二是加大农业内部结构调整;三是根据区域特点和市场需求,科学、合理地制定不同地区应优先发展的产业,并给予扶持;四是完善和配套相关产业发展体系。

关键词 农业产业结构;灰色关联度;无量纲化;评价