Grey Relational Analysis on Industrial Structure of Animal Husbandry in Inner Mongolia

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Abstract This paper introduces the connotation of grey relation and computation method of grey relational degree. Based on grey relational model and relevant data during 2003 - 2012, this paper performs an empirical analysis of the internal structure of agricultural economy and the internal structure of animal husbandry in Inner Mongolia. The results show that animal husbandry and farming are two important sectors of agricultural economy in Inner Mongolia, and within animal husbandry, the influence of dairy cow, mutton, beef and goat wool production is most obvious. Based on this, this paper puts forth the following recommendations: stabilizing the dominant position of farming and animal husbandry in the agricultural economy; continuing to adjust and optimize the internal structure of agricultural economy; reasonably and guide the development of various industries within animal husbandry.

Key words Animal husbandry, Industrial structure, Grey correlation analysis, Inner Mongolia

1 Introduction

Inner Mongolia, officially Inner Mongolia Autonomous Region or Nei Mongol Autonomous Region, is an autonomous region of the People's Republic of China, located in the north of the country, containing most of China's border with Mongolia (the rest of the China-Mongolia border is taken up by the Xinjang and Gansu provinces) and a small section of the border with Russia. Inner Mongolia is rich in farming and animal husbandry resources, and it is one of China's 13 major grain producing areas (2010), and the total annual number of livestock has been stabilized at over 100 million for nine consecutive years (2013). Yield of milk, meat and other animal products ranks first in the country, and it becomes an important national commodity grain base and livestock base. From the aggregate, the added value of primary industry in Inner Mongolia was 159.94 billion yuan in 2013, 3.06 times that in 2004, an average annual increase of 11.8%. From the structure, the total output value of farming, forestry, animal husbandry and fishery in Inner Mongolia was 244.93 billion yuan in 2012, and the output value of farming and animal husbandry was 87.65 billion yuan and 111.89 billion yuan, respectively, accounting for 35.79% and 45.68% of total output value respectively. Both farming and animal husbandry have made great strides. The changes in animal husbandry industrial structure will inevitably bring about development of farming and animal husbandry and increase in income of farmers and herdsmen. Using the grey relational analysis, we analyze the industrial structure of animal husbandry in Inner Mongolia, in order to provide a reference for optimizing the industrial structure of animal husbandry, and promoting the development of farming and animal husbandry.

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2 Research methods, data sources and indicator selection

2.1 Research methods Grey relational analysis uses a specific concept of information. It defines situations with no information as black, and those with perfect information as white. However, neither of these idealized situations ever occurs in real world problems. In fact, situations between these extremes are described as being grey, hazy or fuzzy. Therefore, a grey system means that a system in which part of information is known and part of information is unknown. With this definition, information quantity and quality form a continuum from a total lack of information to complete information—from black through grey to white. Since uncertainty always exists, one is always somewhere in the middle, somewhere between the extremes, somewhere in the grey area. Grey analysis then comes to a clear set of statements about system solutions. At one extreme, no solution can be defined for a system with no information. At the other extreme, a system with perfect information has a unique solution. In the middle, grey systems will give a variety of available solutions. Grey analysis does not attempt to find the best solution, but does provide techniques for determining a good solution, an appropriate solution for real world problems. The steps of grey relational analysis are as follows:

Selecting the reference sequence $X_0 = \{x_0(k), k = 1, 2, \cdots, n\}$; comparative sequence $X_i = \{x_i(k), k = 1, 2, \cdots, n\}$, $(i = 1, 2, \cdots, m)$.

Due to difference in the data units of the reference sequence and comparative sequence, there is a need to make the original sequence dimensionless. The commonly used methods include initial value, mean value and interval value. This analysis uses the initial value method, and its formula is as follows:

$$x'_i(k) = \frac{x_i(k)}{x_i(1)}, k = 1, 2, \cdots, m.$$

Then the grey relational degree $\gamma(X_0, X_i)$ of X_0 and X_i is defined as follows:

$$\gamma(X_0,X_i)=\frac{1}{n}\sum_{k=1}^{n}\gamma(x_0(k),x_i(k))$$

where $\gamma(x_0(k),x_i(k))=\frac{\min\limits_i\min\limits_k|x_0(k)-x_i(k)|+\xi\max\limits_i\max\limits_k|x_0(k)-x_i(k)|}{|x_0(k)-x_i(k)|+\xi\max\limits_i\max\limits_k|x_0(k)-x_i(k)|}$; ξ is the identification coefficient, the smaller the value of ξ, the greater the identification capacity, $\xi\in[0,1]$, generally $\xi=0.5$.

2.2 Indicator selection When analyzing the internal structure of total output value of farming, forestry, animal husbandry and fishery, the reference sequence is the total output value of farming, forestry, animal husbandry and fishery, and the comparative sequence is the total output value of farming, total output value of forestry, total output value of animal husbandry, and total output value of fishery. When analyzing the internal structure of animal husbandry, the reference sequence is the total output value of animal husbandry ($X_0/10^4$ yuan); the comparative sequence is milk production ($X_1/10^4$ t), beef production ($X_2/10^4$ t), pork production ($X_3/10^4$ t), egg production ($X_4/10^4$ t), mutton production ($X_5/10^4$ t), fine wool production ($X_6/10^4$ t), goat wool production ($X_7/10^4$ t), semi-fine wool production ($X_8/10^4$ t), and cashmere production ($X_9/10^4$ t).

2.3 Data sources The data used in this article are from *China Statistical Yearbook* and *Inner Mongolia Statistical Yearbook* from 2004 to 2013.

3 Grey relational analysis of animal husbandry industrial structure in Inner Mongolia

3.1 Grey relational analysis of the internal structure of agricultural economy in Inner Mongolia We select total output value of agriculture (X_1), total output value of farming (X_2), total output value of forestry (X_3), total output value of animal husbandry (X_4), total output value of fishery (X_5) as the related behavioral factors for grey relational analysis, as shown in Table 1.

Table 1 Original sequence for grey relational analysis Unit: 10^8 yuan

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
X_0	666.4	851.3	980.2	1058.5	1276.4	1526.0	1571.0	1843.6	2204.5	2449.3
X_1	336.0	411.5	473.9	542.2	620.4	717.0	731.9	900.4	1057.8	1172.0
X_2	264.0	333.5	383.8	433.8	475.2	568.3	528.2	656.9	787.9	876.5
X_3	47.9	46.6	39.8	49.0	63.7	73.0	78.2	76.6	93.2	97.8
X_4	267.1	374.7	444.6	439.2	560.0	700.0	721.4	822.4	998.3	1118.9
X_5	4.9	6.0	7.3	9.1	11.0	12.0	12.9	15.9	23.6	26.1

Data source: Inner Mongolia Statistical Yearbook (2004 - 2013).

Table 2 The absolute relational degree, relative relational degree and comprehensive relational degree between main behavioral factors and related behavioral factors

Main behavior	Related behavior	Absolute relational degree	Relative relational degree	Comprehensive relational degree
Total output value of farming, forestry, animal husbandry and fishery	Total output value of agriculture	0.7318	0.9615	0.8466
	Total output value of farming	0.6718	0.9368	0.8043
	Total output value of forestry	0.5118	0.6789	0.5953
	Total output value of animal husbandry	0.7437	0.9145	0.8291
	Total output value of fishery	0.5050	0.8751	0.6901

From Table 1 and Table 2, it can be found that during 2003 - 2012, the output value of agriculture and animal husbandry occupied an overwhelmingly dominant position in the total output value, and the growth of total output value of animal husbandry was faster than that of agriculture. Within the agricultural economy, in terms of the impact on main behavior, various relevant behaviors are in the order of total output value of agriculture > total output value of animal husbandry > total output value of farming > total output value of forestry > total output value of fishery. If we exclude the industrial and commercial output value of rural households and output value from the collection of wild plants, they are in the order of total output value of animal husbandry > total output value of farming > total output value of forestry > total output value of fishery. Conspicuously, the animal husbandry economy has become the most important sector in the agricultural economy. Horizontally, the comprehensive relational degree of output value of farming and animal husbandry is close, indicating that the development trend of farming and animal husbandry is similar to that of "large-scale agriculture", and the complementarity between farming and animal husbandry is obvious.

3.2 Grey relational analysis of the internal structure of animal husbandry economy in Inner Mongolia We choose total output value of animal husbandry (X_0) as the main behavioral factor, and milk production (X_1), beef production (X_2), pork production (X_3), egg production (X_4), mutton production (X_5), fine wool production (X_6), goat wool production (X_7), semi-fine wool production (X_8) and cashmere production (X_9) as the relevant factors, to establish the indicator system for the grey relational analysis of the internal structure of animal husbandry economy, and build the time series group for grey relational analysis based on the data, as shown in Table 3. First, we perform the nondimensionalization and calculate the absolute difference between main behavior series and related behavior series, as shown in Table 4. Second, from Table 4, the range can be calculated (xmax:

3.1526; xmin: 0.0000), and the grey relational degree is shown in Table 5. In terms of the grey relational degree in Table 5, the factors are sequenced in the order of milk production > mutton production > beef production > goat wool production > cashmere production > egg production > fine wool production > pork production > semi-fine wool production. Thus it can be found that the main factors causing changes in total output value of animal husbandry in Inner Mongolia during 2003 – 2012 are the production of milk, mutton, beef and goat wool (0.7 and above), followed by the production of cashmere, eggs, fine wool, pork and semi-fine wool. It indicates that the industries of dairy cow, sheep, beef cattle and goat wool have played a significant role in promoting the development of animal husbandry in Inner Mongolia over the past decade while the industries of pig, egg and cashmere have played a weak role in promoting the development of animal husbandry.

Table 3 The time series group for grey relational analysis

Unit: 10^8 yuan, 10^4 t

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
X_0	267.1	374.7	444.6	439.2	560.0	700.0	721.4	822.4	998.3	1118.9
X_1	308.0	497.9	691.1	869.2	909.8	912.2	903.1	905.2	908.2	910.2
X_2	24.0	28.7	33.6	38.2	40.6	43.1	47.4	49.7	49.7	51.2
X_3	71.3	81.4	88.0	81.9	60.3	64.7	68.6	71.9	71.3	73.9
X_4	34.4	38.8	46.2	41.3	43.0	45.5	48.9	50.4	52.5	54.5
X_5	45.3	60.4	72.4	76.0	80.8	84.9	88.2	89.2	87.2	88.6
X_6	4.6	4.6	4.5	5.3	5.3	5.2	5.4	5.0	5.9	5.1
X_7	0.6	0.6	0.8	0.8	0.9	1.0	1.8	1.3	1.3	1.2
X_8	1.4	1.4	1.5	1.5	1.3	1.3	1.6	1.5	1.4	1.9
X_9	0.5	0.6	0.7	0.70	0.7	0.8	0.7	0.8	0.8	0.8

Data source: *Inner Mongolia Statistical Yearbook* (2004 – 2013).

Table 4 The absolute difference between reference series and comparison series

Δ_1	0.0000	0.2137	0.5793	1.1777	0.8573	0.3409	0.2313	0.1400	0.7889	1.2339
Δ_2	0.0000	0.2070	0.2645	0.0527	0.4049	0.8249	0.7259	1.0082	1.6667	2.0557
Δ_3	0.0000	0.2612	0.4303	0.4957	1.2509	1.7133	1.7387	2.0706	2.7376	3.1526
Δ_4	0.0000	0.2749	0.3215	0.4437	0.8466	1.2981	1.2793	1.6139	2.2114	2.6048
Δ_5	0.0000	0.0701	0.0670	0.0326	0.3137	0.7474	0.7547	1.1108	1.8135	2.2341
Δ_6	0.0000	0.4028	0.6863	0.4922	0.9444	1.4903	1.5269	1.9920	2.4549	3.0804
Δ_7	0.0000	0.4028	0.3312	0.3110	0.5966	0.9541	0.2991	0.9123	1.5709	2.1891
Δ_8	0.0000	0.4028	0.5931	0.5729	1.1680	1.6922	1.5580	2.0076	2.7376	2.8319
Δ_9	0.0000	0.2028	0.2645	0.2443	0.6966	1.0207	1.3009	1.4790	2.1376	2.5891

Table 5 The relational degree of main behavioral factor and relevant behavioral factors

Main behavior	Relevant factors	Grey relational degree
Total output value of animal husbandry//10^4 yuan	Milk production (t)	0.767 2
	Beef production (t)	0.737 5
	Pork production (t)	0.604 7
	Egg production (t)	0.650 1
	Mutton production (t)	0.755 0
	Fine wool production (t)	0.607 4
	Goat wool production (t)	0.720 0
	Semi-fine wool production (t)	0.597 9
	Cashmere production (t)	0.677 5

4 Conclusions and recommendations

4.1 Conclusions The output value of agriculture and animal husbandry plays a decisive role in promoting the development of agricultural economy, and the animal husbandry economy makes the highest contribution to the total output value of farming, forestry, animal husbandry and fishery. It can be found that there is strong complementarity between farming economy and animal husbandry economy, but the level of development of forestry and fishery is low, and forestry and fishery need to be improved. From the internal structure of animal husbandry economy, dairy, sheep, cattle and goat wool industries have the greatest impact on animal husbandry economy, but the impact of pigs, eggs and cashmere industries is small, indicating that the dairy cow, beef and mutton industries have become the driving force of economic development of animal husbandry while the advantages of traditional cashmere industry gradually decline.

4.2 ecommendations (i) It is necessary to stabilize the dominant position of farming and animal husbandry in the agricultural

economy in Inner Mongolia, increase policy and financial support, and use farming and animal husbandry subsidies and insurance to enhance the enthusiasm for production and ensure the supply of agricultural and livestock products. (ii) It is necessary to continue to adjust and optimize the internal structure of the agricultural economy, consolidate the dominance of farming and animal husbandry economy, accelerate the development of forestry and fishery economy, and efficiently combine the farming, animal husbandry, forestry and fishery, to make agricultural industry structure more reasonable and advantages of agricultural economy more obvious. (iii) It is necessary to reasonably guide the development of various industries within animal husbandry, make dairy product and beef and mutton industry become the leading industry, and make the egg, pig and cashmere industry become the characteristic competitive industry.

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irrigation without adequate drainage. Long-term experiments have provided some of the best data on how various practices affect soil properties essential to sustainability. The key of construction of ecological agriculture lies in the selection of appropriate mode of ecological agriculture through evaluation and design. The development of ecological agriculture can help to fully use a variety of land resources, reduce the area of bare ground, prevent soil erosion and desertification, mitigate floods and storms, improve agricultural productivity and land and resource utilization rate; increase rural incomes and provide new channels of employment; provide agricultural products with comparative advantage, break trade barriers and increase agricultural exports.

3.5 The development of urban agriculture The agricultural development mode should be transformed to constantly upgrade and optimize agricultural structure, and develop multifunctional agriculture. Agriculture has not only the food security function, but also the functions of material supply, ecological protection, tourism and leisure. Urban agriculture is the practice of cultivating, processing, and distributing food in or around a village, town, or city. Urban agriculture can also involve animal husbandry, aquaculture, agroforestry, urban beekeeping, and horticulture. These activities occur in peri-urban areas as well. Urban agriculture can reflect varying levels of economic and social development. In the global north it often takes the form of a social movement for sustainable communities, where organic growers, 'foodies', and 'locavores' form social networks founded on a shared ethos of nature and community holism. These networks can evolve when receiving formal institutional support, becoming integrated into local town planning as a 'transition town' movement for sustainable urban development. In the developing south, food security, nutrition, and income generation are key motivations for the practice. In either case, more direct access to fresh vegetables, fruits, and meat products through urban agriculture can improve food security and food safety. The development of urban agriculture can provide a natural leisure environment for the urban residents to meet people's growing demand for getting close to nature. It can also promote new rural construction, increase farmers' income, improve the rural environment, promote coordinated urban and rural development and increase employment.

4 Recommendations for LCA development

4.1 Developing resource-conserving agriculture Full use of the residual energy in agriculture and reasonable use of crop straw resources can help to prevent environmental pollution and fully utilize resources. For example, we can use feed, fertilizer and gasification technology to produce flammable gas under high temperature, high pressure and anaerobic conditions, and we can also use straw to produce ethanol fuel.

4.2 Developing environment-friendly agriculture It is necessary to greatly reduce the application rate of fertilizer and pesticides, mitigate the dependence of agricultural production process on fossil fuels, and take the road of organic and ecological agriculture. For example, we can use manure or compost as an alternative to chemical fertilizers, and improve soil organic matter content; return crop straw to farmland to increase soil nutrients and reduce runoff infiltration; adopt the rotation of crops and introduce earthworms and microorganisms to expand the plant roots' nutritional capacity.

4.3 Developing and promoting the use of new energy It is necessary to promote solar energy and biogas technologies. Popularizing the solar collectors in rural areas is an effective way to develop low-carbon rural areas. In the large-scale livestock breeding, we can use animal feces to produce biogas and obtain biomass energy. It is necessary to transform the development mode of agricultural economy, vigorously promote agricultural economic restructuring and optimization, focus on independent innovation capacity of China's agriculture, and improve the energy-saving and environment-friendly levels of agriculture.