How to Increase Farmers' Income in the Poor Mountainous Areas ?

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Abstract Using the gray system theory and gray relational analysis method, the relationship between added value of hybrid corn, hogs, *Juglans sigillata*, *Pisum Sativum* L., safflower and that of farmers' net income in Bailongjing Village, Wafang Township, Longyang District, Baoshan City, Yunnan Province was analyzed, and the ways to increase farmers' per capita net income were studied. The results showed that economic income of farmers by structure adjustment of agriculture is *Juglans sigillata* > *Pisum Sativum* L. > safflower > hogs > hybrid corn. The study can provide scientific basis for optimizing agricultural industrial structure in Baoshan City, and promoting the rapid growth of farmers' economic income.

Key words Baoshan City, Agriculture, Industrial structure, Gray relational analysis

1 Introduction

There are many difficulties in the sustained economic growth in the poor mountainous areas, and the solution lies in the reform, adjustment and optimization of agricultural industrial structure. In this paper, we use the gray relational analysis to evaluate the crop varieties, and study the relationship between the main characters and yield, the adjustment of agricultural industrial structure and agricultural output value. Since the domestic use of gray relational analysis and gray situation decision to report the crop varieties such as sweet potato[1], rice[2], maize[3-5] and wheat[6], the gray relational analysis has been applied in the adjustment of agricultural industrial structure and farmers' income increase. The gray relation analysis is performed on the agricultural added value and some indicators such as crop yield, meat production and egg production[7], and the result shows that there is the greatest gray correlation between meat production and agricultural economic development. Fan Kuangsheng uses the gray relational analysis method to analyze the relationship between the total agricultural added value and the added value of farming, forestry, animal husbandry and fishery in Henan Province, respectively[8], indicating that the added value of farming occupies the highest proportion and affects farmers' income. The gray relational analysis is performed on the relationship between the total agricultural output value and the variation of farming, animal husbandry and forestry[9], and the results show that farming has the greatest impact on the total agricultural output value. Zhang Ruili and Huang Mingfeng use the data in Xinjiang from 1978 to 2008 to establish the linear function model for the empirical analysis of the correlation between changes in internal structure of agriculture and farmers' income growth in Xinjiang[10], confirming that the adjustment of agricultural structure has a direct impact on farmers' income. Li Guanying uses the gray relational analysis to study the factors influencing the industrial structure of Guangxi[11], and the results show that the three factors affecting the changes in industrial structure of Guangxi are industrial transfer investment, total imports and exports, and regional consumption level. Wang Miao et al. use the gray relational analysis to perform the empirical analysis of agricultural industrial structure and the impact factors in Er'yuan County of Yunnan Province[12], and find that farming is the leading industry, followed by animal husbandry, fishery and forestry. These studies have provided a theoretical basis, but the detailed quantitative analysis of the relationship between agricultural industrial structure and farmers' net income growth has not yet been reported. In order to effectively promote the adjustment of agricultural industrial structure in the poor mountainous areas of Baoshan City in Yunnan Province, we study the relationship between specific industries and rural per capita net income in the underdeveloped mountainous areas[13], and perform the gray relational analysis using the data on farmers' net income growth and net income variation of hybrid corn, hogs, *Juglans sigillata*, *Pisum Sativum* L. and safflower in Bailongjing Village as a typical poor village in Longyang District of Baoshan City from 2004 to 2010, to provide a scientific basis for adjusting agricultural industrial structure and increasing farmers' net income in the poor mountainous areas.

2 Materials and methods

2.1 Overview of the study area Bailongjing Village, under the jurisdiction of Wafang Yi and Miao Township in Longyang District, administers three administrative villages (Sikeshu, Bailongjing and Guga), and seven groups of villagers. There are 465 households, with an agricultural population of 1940 and a labor population of 820. The village covers an area of 19.05 km^2, the altitude is 1310 -2207 m, and the annual rainfall is 1200 mm. It has 305.8 hm^2 of arable land, and 857.4 hm^2 of woodland. It has rich land resources and favorable climate, but it is still a poor village, and farmers' income is mainly dominated by farming. Therefore, based on "3 + 2" poverty alleviation project, Agricultural

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Bureau of Longyang District began to adjust the industrial structure from 2005. In 2010, it promoted the cultivation of 165.3 ha of hybrid corn, 326.7 ha of *Juglans sigillata*, 61 ha of early winter *Pisum Sativum* L. and 49 ha of safflower, and achieved 343.7 t of meat production. The total income of village reached 5.8734 million yuan and rural per capita net income reached 1951 yuan.

2.2 Data selection The data are from the annual report of per capita industrial net income and per capita net income of farmers from 2004 to 2010 in Bailongjing Village, Wafang Township, Longyang District, Baoshan City (Table 1).

Table 1 Per capita industrial net income and per capita net income of farmers

Year	Net income yuan/person	Hybrid corn yuan/person	Hogs yuan/person	*Juglans sigillata* yuan/person	*Pisum Sativum* L. yuan/person	Safflower yuan/person
2004	682.00	361.46	224.99	0.14	8.18	16.37
2005	741.00	420.51	247.2	0.15	10.00	20.67
2006	951.00	485.49	389.05	0.19	13.12	15.03
2007	1138.00	623.85	441.32	0.34	15.70	20.03
2008	1360.00	638.93	655.79	4.62	21.35	13.06
2009	1589.00	662.61	813.57	10.96	46.88	32.42
2010	1951.00	741.38	962.82	35.9	64.52	53.16

2.3 Analysis method Using the gray relational analysis method[14], this paper studies the impact of the development of agricultural industry on per capita net income of farmers.

3 Results and analysis

3.1 Normalization of original data The original data in time series are difficult to be directly compared, and according to the principle of accessibility and comparability, this paper normalizes the original data. The rural per capita net income is defined as Y_{ij}, and the per capita net income of industries is $X_{ij} = (X_{i(1)}, X_{i(2)}, \cdots, X_{i(5)})$ = (hybrid corn, hogs, *Juglans sigillata*, *Pisum Sativum* L., and safflower). In accordance with the normalization requirements ($Y_{ij}/10000$, $Y_{i(1)}/1000$, $Y_{i(2)}/1000$, $Y_{i(3)}/100$, $Y_{i(4)}/100$, $Y_{i(5)}/100$), the normalized results of the data are obtained (Table 2).

Table 2 Normalization of original data

Year	Y_{ij}	$X_{i(1)}$	$X_{i(2)}$	$X_{i(3)}$	$X_{i(4)}$	$X_{i(5)}$
2004	0.068 2	0.361 5	0.225 0	0.001 4	0.081 8	0.163 7
2005	0.074 1	0.420 5	0.247 2	0.001 5	0.100 0	0.206 7
2006	0.095 1	0.485 5	0.389 1	0.001 9	0.131 2	0.150 3
2007	0.113 8	0.623 9	0.441 3	0.003 4	0.157 0	0.200 3
2008	0.136 0	0.638 9	0.655 8	0.046 2	0.213 5	0.130 6
2009	0.158 9	0.662 6	0.813 6	0.109 6	0.468 8	0.324 2
2010	0.195 1	0.741 4	0.962 8	0.359 0	0.645 2	0.531 6

3.2 The absolute difference between normalized series and parameter series According to the data in Table 2 and formula $\Delta ij_{(k)} = |Y_{ij(k)} - X_{ij(k)}|$, we calculate the normalized data and get absolute difference (Table 3).

3.3 Correlation coefficient $\xi_{i(k)}$ Table 3 shows that the minimum difference $\Delta\min = \min\min\Delta ij_{(k)} = \min(0.2933, 0.1568, 0.0493, 0.0136, 0.0054) = 0.0054$, and the maximum difference $\Delta\max = \max\max\Delta ij_{(k)} = \max(0.5463, 0.7677, 0.1639, 0.4542, 0.3365) = 0.7677$. The identification coefficient $\sigma = 0.5$, and according to the correlation coefficient formula $\xi_{i(k)} = (\Delta\min + \sigma\Delta\max)/(\Delta ij_{(k)} + \sigma\max)$, we can calculate the coefficient of correlation between net income of various industries and per capita net income of farmers (Table 4).

Table 3 The absolute difference between the original data

Year	$X_{i(1)}$	$X_{i(2)}$	$X_{i(3)}$	$X_{i(4)}$	$X_{i(5)}$
2004	0.293 3	0.156 8	0.066 8	0.013 6	0.095 5
2005	0.346 4	0.173 1	0.072 6	0.025 9	0.132 6
2006	0.390 4	0.294 0	0.093 2	0.036 1	0.055 2
2007	0.510 1	0.327 5	0.110 4	0.043 2	0.086 5
2008	0.502 9	0.519 8	0.089 8	0.077 5	0.005 4
2009	0.503 7	0.654 7	0.049 3	0.309 9	0.165 3
2010	0.546 3	0.767 7	0.163 9	0.454 2	0.336 5

Table 4 The coefficient of correlation between per capita industrial net income and per capita net income of farmers

Year	$X_{i(1)}$	$X_{i(2)}$	$X_{i(3)}$	$X_{i(4)}$	$X_{i(5)}$
2004	0.295 6	0.720 0	0.863 8	0.979 4	0.812 0
2005	0.533 0	0.699 0	0.852 8	0.950 0	0.753 7
2006	0.502 7	0.582 8	0.816 0	0.926 9	0.886 6
2007	0.435 7	0.547 2	0.787 6	0.911 5	0.827 6
2008	0.439 0	0.430 8	0.821 8	0.843 7	1.000 0
2009	0.438 6	0.374 8	0.898 7	0.561 1	0.708 8
2010	0.418 5	0.338 0	0.710 6	0.464 5	0.540 4

3.4 Calculation of correlation degree

$$r_i = 1/n \sum_{k=1} \xi_{i(k)}$$

where n is the number of samples. The correlation degree between the per capita net income of farmers and five industries (hybrid corn, hogs, *Juglans sigillata*, *Pisum Sativum* L., and safflower) is calculated as follows: $r_1 = 0.437\,6$, $r_2 = 0.527\,5$, $r_3 = 0.821\,6$, $r_4 = 0.805\,3$, $r_5 = 0.790\,0$. It is in the descending order of *Juglans sigillata* > *Pisum Sativum* L. > safflower > hogs > hybrid corn.

4 Conclusions and recommendations

4.1 Conclusions Bailongjing Village in Wafang Township of Longyang District in Baoshan City has excellent dimensional climate resources. Under the support of "3 + 2" poverty alleviation project, the benefit of three industries (hybrid corn, hogs and *Juglans sigillata*) has started to appear. Hybrid corn cultivation and hog breeding are realistic industries which are of great signifi-

cance to increasing farmers' income. *Juglans sigillata* cultivation generally takes more than eight years to enter full bearing period, so it is a long-term industry making tremendous contribution to increasing farmers' income in the long term. *Pisum Sativum* L. and safflower are affected by winter and spring rainfall, but there is less investment and high yield, thereby making great contribution to increasing farmers' net income. Thus, *Juglans sigillata*, *Pisum Sativum* L. and safflower will become the major industries for further improving farmers' net income in the future.

4.2 Recommendations (i) It is necessary to continue to consolidate and enhance hybrid corn cultivation and hog breeding. Special attention should be given to increase of hybrid corn yield and total amount of hogs for sale. (ii) It is necessary to expand the growing area of *Juglans sigillata* in the regions at an altitude of 1800 – 2500m while strengthening the promotion of the use of production increase and productivity improvement technology for young plantations. (iii) It is necessary to adjust the spring crop planting structure according to local conditions. The regions at an elevation of less than 1600m should develop early winter *Pisum Sativum* L. with Zhongwan 6 as the main variety, or use the efficient cultivation of three crops (safflower, *Pisum Sativum* L. and corn) a year[15]. The regions at an elevation of above 1600m should plant safflower with Yunhong 2 and 3 as main varieties, in order to further expand the space for increasing farmers' net income.

5 Discussions

Gray relational analysis method normalizes the original data, and this paper performs the gray relational analysis of per capita net income of farmers and various industries in the underdeveloped mountainous areas[7]. The results show that speeding up the adjustment of agricultural industrial structure is the most fundamental way to increase the per capita net income of farmers in the underdeveloped mountainous areas. This method is used to analyze the relationship between industrial development and industrial structure adjustment, with few calculation steps and strong operability. It can effectively guide the adjustment of agricultural industrial structure, and the normalization of the original data can be widely used in the gray relational analysis between the adjustment of agricultural industrial structure and farmers' net income growth.

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pling tools, sampling process, pretreatment, packaging, transfer, storage conditions and sample delivery) during the implementation of the sampling can ensure the representativeness and authenticity of the sample.

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