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Regional Agricultural Input – Output Model and Countermeasure for Production and Income Increase of Farmers in Southern Xinjiang, China

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Abstract Agricultural input and output status in southern Xinjiang, China is introduced, such as lack of agricultural input, low level of agricultural modernization, excessive fertilizer use, serious damage of environment, shortage of water resources, tremendous pressure on ecological balance, insignificant economic and social benefits of agricultural production in southern Xinjiang, agriculture remaining a weak industry, agricultural economy as the economic subject of southern Xinjiang, and backward economic development of southern Xinjiang. Taking the Aksu area as an example, according to the input and output data in the years 2002 –2007, input – output model about regional agriculture of the southern Xinjiang is established by principal component analysis. DPS software is used in the process of solving the model. Then, Eviews software is adopted to revise and test the model in order to analyze and evaluate the economic significance of the results obtained, and to make additional explanations of the relevant model. Since the agricultural economic output is seriously restricted in southern Xinjiang at present, the following countermeasures are put forward, such as adjusting the structure of agricultural land, improving the utilization ratio of land, increasing agricultural input, realizing agricultural modernization, rationally utilizing water resources, maintaining eco-environmental balance, enhancing the awareness of agricultural insurance, minimizing the risk and loss, taking the road of industrialization of characteristic agricultural products , and realizing the transfer of surplus labor force.

Key words Regional agriculture, input – output model, Production and income increase, Principal component analysis, Econometric model, China

Land resource refers to the land that can satisfy or soon satisfy the material life and production needs of human in production at present or in the foreseeable future[1]. Economic benefit usually reflects the land use status and use efficiency. Through the material and labor input of people, land produces new value and people also receives income from the land. Rational use of land resources plays an important role in the economic development of a region. Although Xinjiang has a vast territory and rich resources, scarcity status of land resource is getting worse with the increase of population and human demands. At present, research on the regional agricultural input – output model in southern Xinjiang is of important theoretical and practical significance to the rational and efficient use of land resources and to the exertion of potential production value of the land[2-3]. Based on the comprehensive consideration of social, economic and ecological benefits, regional agricultural input – output model in southern Xinjiang is established in order to provide references for the agricultural development in southern Xinjiang.

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1 Status analysis on the agricultural input – output of southern Xinjiang

Agricultural economy is the economic pillar for southern Xinjiang, as well as a major growth point of economy in southern Xinjiang. With the development of economy and society, ecological environment is under great pressure and challenge in southern Xinjiang. At the same time, agricultural economy in southern Xinjiang has also suffered from the impact of environmental damage to a certain degree. Thus, the future development of agriculture in southern Xinjiang has become the overwhelming problem for the regional economic development and social harmony and stability in southern Xinjiang, which is worthy of further research. In general, agricultural economic benefit is poor in southern Xinjiang with relatively low overall benefit. Problems of agricultural input – output in southern Xinjiang are mainly in five aspects.

1.1 Insufficient input in agriculture; relatively low level of agricultural modernization Table 1 reports that the cultivated land area in five areas of southern Xinjiang is 1 305.42 thousand hectares at the end of the year 2007, accounting for 48.2% of the overall cultivated land area in Xinjiang. Use amount of the total power of agricultural machinery is 4 221 937 Kilowatt, only accounting for 43.3% of the whole Xinjiang. Therefore, it can be concluded that the input is insufficient in agricultural machinery power in southern Xinjiang. At the same time, fixed assets investment in five areas of southern Xinjiang is 3 412 980 thousand yuan, only accounting for 40.3%. Thus, it can be concluded that there is a serious shortage of agricul-

tural input in southern Xinjiang, as well as a relatively low level of agricultural modernization. Insufficient input in agriculture reflects that agriculture in southern Xinjiang is mostly at a lower stage of planting and both secondary industry and tertiary industry related with agricultural products are at an extremely slow speed of development, which severely impacts the overall level of economic development in southern Xinjiang.

Table 1 Status of agricultural input – output in southern Xinjian

Area	Agricultural income $\times 10^4$ Yuan	Use amount of chemical fertilizer ton	Overall machinery power kW	Effective irrigation area $\times 10^4$ hm^2	Employees	Annual average wage Yuan	Agricultural fixed assets investment $\times 10^4$ Yuan	Cultivated land area at the end of year $\times 10^4$ hm^2	National revenue $\times 10^4$ Yuan
Xinjiang	8 396 841	842 723	9 758 544	244.48	3 533 406	13 013	846 093	270.88	228 386
Bazhou	912 405	95 169	902 257	19.68	167 849	14 187	102 246	20.47	31 385
Aksu	1 055 780	152 665	1 340 356	34.72	507 578	16 323	153 207	37.93	12 655
Kizilsu prefecture	115 514	12 917	172 102	3.04	100 225	18 394	1 853	3.08	1 018
Kashgar	1 723 347	209 260	1 398 513	50.90	740 073	14 847	46 468	51.57	12 180
Khotan	517 983	50 006	408 709	16.50	458 400	11 016	37 524	17.49	9 520

1.2 Excess of fertilizer; serious damage of environment According to Table 1, use amount of chemical fertilizer in the five areas of southern Xinjiang reaches 520 017 tons, which accounts for 61.7% of the overall use amount of Xinjiang and is far greater than the proportion of cultivated land area of the five areas in the total area of Xinjiang at the end of the year (48.2%). Although the five areas have input a high proportion of fertilizer, its economic benefit is insignificant. Therefore, it can be concluded that southern Xinjiang has an excess of fertilizer during agricultural production, which seriously influences the organic ingredient content of soil and destroys the production potential of land. Moreover, abuse of chemical fertilizer can not bring considerable economic benefits for local farmers, but leads to soil compaction to a certain extent and greatly destroys the local ecological environment.

1.3 Lack of water resource; huge pressure on maintaining the balance of ecological environment According to the two indices in Table 1, cultivated land area at the end of year in southern Xinjiang is 1 305.42 thousand hectares, accounting for 48.2%; while the effective irrigation area is 1 248.29 thousand hectares in southern Xinjiang, accounting for 51.1% of that in Xinjiang. The proportions of the two indices are far lower than the proportion of land area, due to the lack of water resource. Under the pressures of maintaining the balance of ecological environment and fully utilizing the land to develop agricultural economy, it is particularly important to coordinate the relationship between land use and water resources allocation, because of the limited water resources in most areas of southern Xinjiang. If the two are poorly treated, soil desertification and alkalization may be caused in many areas and the ecological environment may suffer from more severe damage.

Table 2 Agricultural input – output in Aksu in the years 2002 – 2007

$\times 10^4$ Yuan

Year	Agricultural output value X_1	Sowing quantity X_2	Fertilizer X_3	Fuel X_4	Pesticide X_5	Agricultural plastic film X_6	Electricity consumption X_7	Purchase of small farm tools X_8	Other material consumption X_9
2002	492 976.5	22 064.16	95 916.72	18 048.19	5 196.95	18 648.5	6 583.78	147 64.5	18 779.79
2003	506 322	24 162.67	109 833.6	23 520.94	5 884.49	20 318.64	9 261.32	16 344.43	32 865.48
2004	5 333 527	25 598.11	113 429.1	25 226.98	5 995.03	24 921.34	10 443.64	17 531.66	36 829.67
2005	581 763.3	28 783.28	134 545.6	30 146.32	9 457.51	30 367.82	11 695.9	21 039.5	43 936.36
2006	644 513.4	30 192.62	150 127.8	36 524.23	8 385.99	32 560.01	15 122.44	24 089	51 538.09
2007	841 838	34 818.8	193 591	43 788.5	8 724.29	39 078.5	9 830.38	28 208.5	21 982.45

Year	Technology fee X_{10}	Irrigation cost X_{11}	Labor cost X_{12}	Mechanical cultivation cost X_{13}	Insurance premium X_{14}	Other production and service expenditure X_{15}
2002	2 019.94	28 607.35	28 756.53	27 138.71	3 776.93	14 318.56
2003	2 276.45	28 069.4	34 821.08	19 805.3	4 757.7	15 050.95
2004	3 172.93	29 982.36	40 533.99	23 189.34	5 012.05	17 580.25
2005	3 501.07	30 667.16	54 159.59	25 678.28	5 577.73	18 667.74
2006	3 602.79	29 145.59	60 727.42	24 479.92	5 765.8	21 771.26
2007	4 336.09	4 836.82	84 575.63	37 638.6	4 944.58	18 267.27

1.4 Insignificant economic and social benefits of agricultural production; weak industry of agriculture in southern Xinjiang Table 1 indicates that agricultural employees in the five areas of southern Xinjiang account for 55.9% of the total agricultural employees in Xinjiang in the year 2007; but the overall agricultural income in the five areas only occupies 51.5%. Therefore, economic benefit of agriculture in southern Xinjiang is not significant. Besides, except Khotan, annual av-

erage wage of agricultural employees in the other 4 areas is higher than that in Xinjiang, because agriculture dominates the economic development in southern Xinjiang and agricultural development in southern Xinjiang is in a superior position. However, national revenue of the five areas in southern Xinjiang only accounts for 29.2% of the national revenue of the whole Xinjiang, indicating that although agriculture in southern Xinjiang takes the dominant position in Xinjiang, the social benefit produced by agriculture is insignificant in southern Xinjiang. This reflects that agriculture is still a weak industry.

1.5 Agricultural economy as the main body of the economy of southern Xinjiang; backward overall economic development level in southern Xinjiang According to the data in Table 1, annual average wage of farmers in most southern Xinjiang is higher than that in Xinjiang in the year 2007, indicating that agriculture plays an important role in the social and economic development of southern Xinjiang. However, national revenue of the five areas in southern Xinjiang only accounts for 29.2% of the national revenue of the whole Xinjiang, showing that the overall economic development level is backward in southern Xinjiang due to the relatively low development levels of secondary industry and tertiary industry in southern Xinjiang, the serious shortage of agricultural industrialization development, the short industrial chain of agricultural products, and the inadequate exploitation of the value of agricultural products. Thus, both the economic and social benefits of agricultural development in southern Xinjiang are poor, which affects the coordinated development of economy and society in southern Xinjiang to a certain extent.

2 Empirical study on the agricultural input – output in southern Xinjiang

2.1 Data source, research method and econometric model

2.1.1 Data source. Data are from the 2002 – 2007 *Statistical Yearbook of Xinjiang Production and Construction Corp*. The major indices include the fertilizer, fuel, pesticide, agricultural output value, sowing quantity, agricultural plastic film, electricity consumption, the purchase of small farm tools, other material consumption, insurance premium, technology fee, irrigation cost, mechanical cultivation cost, labor cost and other production and service expenditure. For the sake of simplification, Aksu is taken as an example to establish the model.

2.1.2 Research method. According to the analysis of current status, different areas have high similarity degree in input and output. Therefore, a certain area can be selected as a representative to carry out research. Based on the indices mentioned above, impact of input index on output in southern Xinjiang is studied in order to establish an agricultural input – output model in southern Xinjiang. Since multicollinearity exists in a lot of economic indices, Principal Component Analysis should be conducted before solving the model[4-5]. Therefore, main factors affecting economic development can be obtained, as well as the target factor associated with the main factor. Finally, corresponding econometric model can be determined.

2.1.3 Econometric model. Based on the analysis of the impact of industrial structure on economic contribution, we try to use the analysis model of the impact of industrial structure on economic contribution in order to carry out empirical study on agricultural input – output in southern Xinjiang[6-7]. Impact of input on output can be expressed as

$$Y = F(X_1, X_2, \cdots, X_n, A),$$

where Y is total output, X_i is the inputs of material, labor, economic system, scientific technology and other production elements, $i = 1, 2, \cdots, n$.

According to the national economy statistics accounting, total output is equal to the sum of the outputs of all the input factors. However, under certain economic system, phenomenon of alignment exists in some input factors. Some input factors have made no significant contribution to the total output individually, but their combination with other input factors has great impact on the total output. These factors are treated as a part of economic system and the rest factors are treated as the factors not affected by economic system. Therefore, total output is not just the sum total of all the input factors. In order to describe the contribution of industrial structure to economy under low economic growth, the following model is adopted to describe the relationship between output benefit and input factor:

$$\log Y = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \cdots + \beta_n \log X_n + \varepsilon,$$

where β_0, β_1, $\cdots$, β_n are the weight coefficients of input factors.

2.2 Empirical study on the agricultural input – output in southern Xinjiang——A case of Aksu area

2.2.1 Data standardization. The original data is treated by Z standardized method in order to eliminate the impact of different dimensions[5].

2.2.2 Principal component factor and the determination of its influencing factor.

2.2.2.1 Determination of influencing factor. Firstly, DPS software is used to obtain the eigenvalue and cumulative contribution rate of principal component (Table 3)[8]. Variance contribution rate is an index to evaluate the relative important degree of factor, representing the relative important degree of principal component. During statistics, it is generally believed that more than 85% cumulative contribution rate of principal component can retain effective information. Therefore, factors 1 and 2 are selected as the principal component factors.

Table 3 Eigenvalue and cumulative contribution rate of principal component

Principal component	Eigenvalue	Percentage %	Cumulative contribution rate// %
F_1	9.952 8	66.351 9	66.351 9
F_2	3.564 9	23.766 0	90.117 8
F_3	1.060 7	7.071 1	97.188 9
F_4	0.245 6	1.637 3	98.826 3
F_5	0.176 1	1.173 7	100.000 0

2.2.2.2 Determination of the factors affecting principal component factor. According to the result of DPS software, loading matrix of principal component is obtained, that is, the factor loading matrix after orthogonal rotation (Table 4). Coefficient of load represents the explanation degree of index variable variance by principal component. In the principal component analysis, load greater than 0.3 is regarded as significant, so we se-

lect loads greater than 0.3 to explain the original variable. Table 4 shows that the most important factors affecting factor 1 are X_2, X_3, X_4, X_6, X_8, X_{10} and X_{12}, that is, sowing quantity, fertilizer, fuel, agricultural plastic film, purchase of small farm tools, technology fee, and labor cost; and the most important factors affecting factor 2 are X_7, X_9, X_{11} and X_{14}, that is, electricity consumption, other material consumption, irrigation cost, and insurance premium.

2.2.3 Determination of model and its economic significance. According to the econometric model and the analysis mentioned above, two models can be established. One is the model constituted by factor 1 and its associated factor, the other is the model constituted by factor 2 and its associated factor. Test on factor 1 shows that only when the combination of X_2, X_3 and X_{12} has the best effect, can we obtain an idea result. Based on this, it can be concluded that the original model is not perfect enough and further amendment is needed. After conducting the Eviews software, it is obtained that the optimum value of D-W (residual error) is 2.07; X_2, X_3 and X_{12} can pass T test and F test under 95% reliability, which further shows that the model is reasonable[9]. Hence, the model constituted by factor 1 and its associated factor is

$$\log(Y) = 0.871\ 857\ 181 + 0.115\ 948\ 205\log X_2 + 0.496\ 511\ 995\log X_3 + 3.203\ 893\ 212\log X_{12}.$$

Table 4 Loading matrix of principal component

Index	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
X_1	−0.047 5	0.109 1	0.936 9	0.125 5	−0.041 5
X_2	0.313 6	−0.070 3	0.024 1	−0.016 8	−0.132 9
X_3	0.304 5	−0.137 6	−0.005 2	−0.170 4	−0.124 7
X_4	0.312 3	−0.052 2	0.010 8	−0.266 6	−0.104 3
X_5	0.280 1	0.104 3	−0.241 2	0.687 2	−0.126 3
X_6	0.315 0	−0.041 7	0.052 1	0.102 1	0.062 9
X_7	0.202 6	0.395 1	−0.034 0	−0.333 4	0.193 4
X_8	0.313 0	−0.069 7	−0.026 3	−0.157 4	0.060 2
X_9	0.098 8	0.502 2	−0.055 8	−0.019 4	−0.046 0
X_{10}	0.307 2	−0.003 6	0.212 7	0.226 7	−0.027 9
X_{11}	−0.197 9	0.397 6	−0.079 4	0.304 9	0.311 2
X_{12}	0.309 2	−0.114 9	0.013 5	−0.037 0	−0.062 2
X_{13}	0.202 2	−0.382 1	0.041 2	0.286 1	0.535 7
X_{14}	0.220 7	0.367 5	0.006 9	0.111 4	−0.415 8
X_{15}	0.252 9	0.288 7	0.046 5	−0.157 5	0.574 2

The equation shows that every 1 yuan seeds will bring 0.12 yuan agricultural income, indicating that seed has relatively great contribution to agricultural output. Moreover, fertilizer has a contribution rate of 49.7% to agricultural economic growth, showing that fertilizer is fairly important to agricultural economic growth. However, during agricultural production, application of fertilizer should be based on the actual needs of the crop. When the application of fertilizer exceeds the actual needs of crop, fertilizer has no significant impact on economic output. When output has reached a certain standard quantity, simply increasing the input of labor has no obvious contribution to the output benefit of agriculture. Therefore, it can be seen that promoting agricultural mechanization is of great significance to improve the production benefit of agriculture[10-11]. Constant in this model means that the contribution rate of other indices to agriculture is 87.2%.

Test shows that the indices associated with factor 2 obtain an ideal result, except the electricity consumption and the other material consumption. After conducting the Eviews software, it is obtained that the optimum value of D-W (residual error) is 2.52, which is still relatively small[9]. And X_{11} and X_{14} can pass T test and F test under 95% reliability. Therefore, it can be concluded that the model is relatively idea. Hence, the model constituted by factor 2 and its associated factor is

$$\log(Y) = -1.231\ 881\ 274 - 0.639\ 285\ 335\ 7\log X_{11} + 0.230\ 612\ 029\log X_{14}.$$

The equation shows that irrigation cost is not only a factor affecting the agricultural development of southern Xinjiang, but also is vital to the agricultural development of the whole southern Xinjiang. The lack of water resources in southern Xinjiang is a bottleneck of the agricultural development in southern Xinjiang. Insurance premium has a contribution rate of 0.23 to agricultural development, showing that insurance premium has great impact on agricultural development. Therefore, farmers should strengthen the awareness of agricultural insurance in order to avoid or reduce the loss of agricultural disasters.

2.2.4 Supplementary specification of related model. There are many other indices hindering the development benefit of agriculture. But these indices can not be eliminated to realize the optimal benefit of agricultural development, because these indices are necessary for agricultural production, which can be verified by the index of irrigation cost. Besides, there are many similarities in agricultural development among different areas of southern Xinjiang. Index factors are almost the same, although there are differences among the contribution rates of index factors in agricultural development. Hence, the model established can be extended into other areas of southern Xinjiang. And the research methods during model establishment can be popularized in the research and evaluation of agricultural development in other areas.

3 Countermeasures for increasing the output and income of farmers in southern Xinjiang

southern Xinjiang is in the region with sand dust and a lot of disasters. The lack of water resources has causeed a large area of land in idle state. Moreover, the insufficient use of water resources leads to huge difficulty in the exploitation of land resources[12]. Farmers in southern Xinjiang are overly dependent upon primary planting; secondary tertiary industries related with agriculture are few and small in scale with short industrial chain and low value-added of agricultural products, and poor comprehensive level of social benefits[13]. Industrial structure in most areas of southern Xinjiang is not reasonable. Especially the relatively small planting area of fruit industry has seriously restricted the agricultural economic output of southern Xinjiang[13]. Therefore, suggestions for the agricultural economic development in southern Xinjiang are put forward from five aspects.

3.1 Adjusting the structure of agricultural land; improving the utilization ratio of land In the aspect of adjusting the structure agricultural land use, each unit should abandon

the unreasonable agricultural land use according to its existing structure. southern Xinjiang should ensure the grain security within water quota, improve production level of cotton according to the guideline of " cotton reduction, livestock increase, fruit increase" , develop characteristic industry according to its own characteristics and existing conditions, fully raise the utilization rate of land, and form its own regional advantage and regional brand.

3.2 Increasing agricultural input; realizing agricultural modernization Firstly, southern Xinjiang should increase capital input for agricultural mechanization, reduce labor cost and increase productivity effect. Mechanization has made more and more contributions to agriculture. And labor cost under low mechanization level has significantly hindered the improvement of agricultural benefit. Therefore, capital input for agricultural mechanization should be increased in order to improve the agricultural benefit. Secondly, southern Xinjiang should increase capital input for agriculture, realize agricultural modernization, extend the industry chain of agriculture, actively promote the intensive processing of farm products, increase farmers' income while liberating the productive forces. At the same time, southern Xinjiang should cultivate leading enterprises, extend industrial chain, improve the value-added of agricultural products, establish the coupling mechanism of agricultural interests, achieve the interaction among three industries, cultivate agriculture industrialization leading enterprise with good benefit, high correlation degree, and strong driving force, and create several well-known brands.

3.3 Rationally utilizing water resources; maintaining eco-environmental balance Water resource is not only vital to agricultural production, but also is a core element to maintain the ecological balance of southern Xinjiang. Therefore, it is necessary to rational use every drop of water. At present, there is a serious disorder between ecological balance of water resources and the land use in southern Xinjiang. In order to protect the ecological environment and ensure the existing living environment, southern Xinjiang should stop the reclamation of new land, fully use the current land, and improve the use efficiency of land. When realizing the rapid development of agricultural economy, southern Xinjiang should fully consider the balance of ecological environment and realize the harmonious development between man and nature.

3.4 Enhancing the awareness of agricultural insurance; minimizing the risk and loss southern Xinjiang is in the region with sand dust, a lot of disasters and the lack of water resources. Excessive land reclamation for short-term economic benefits has seriously destroyed the ecological environment in southern Xinjiang. Both deterioration of natural condition and man-made damage have led to the deteriorating ecological environment and the growing agricultural disasters in southern Xinjiang. Therefore, agricultural insurance becomes more important for farmers to avoid risks. Farmers' awareness of agricultural insurance should be enhanced, so as to minimize the risk of loss. Meanwhile, the state and local government should reinforce the supervision and reasonable standard of agricultural insurance, so that farmers will receive compensation for the loss in time.

3.5 Taking the road of industrialization of characteristic agricultural products; realizing the transfer of surplus labor force southern Xinjiang should strengthen the industrialization of characteristic agricultural products, take the road of deep processing of agricultural products, extend the agricultural industrial chain, and realize the transfer of surplus labor force. Due to the popularization of agricultural mechanization, agricultural labor forces are liberated. And the rural surplus labor forces are transferred into secondary and tertiary industries related with characteristic agricultural products to increase the income of farmers and to realize the harmonious and sustainable development southern Xinjiang. Besides, taking the road of industrialization of characteristic agricultural products and realizing the fully rational use of land resources and characteristic resources can help to reduce the pressure on agricultural economic output, improve ecological environment, and realize the harmony among man, nature and society.

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