Comparative Advantage Analysis of the Main Grain Crops in Henan Province

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Abstract Based on the summarization of the status quo of the research both at home and abroad, the changing trend of the production of the main grain crops, covering the planting structure, seed structure and the trend of the per unit yields of garlic are analyzed. According to the comparative advantage theory, the comprehensive comparative advantages indices, which have been revised, can be used as the main research methods. By using the relevant data from 2000 to 2006, the scale comparative advantage, the efficient comparative advantage and the comprehensive comparative advantages of the main grain crops (wheat, millet, corn, soybean, rice and tuber crops) in each city of Henan Province are measured. The results show that among the main grain crops in Henan Province, only the wheat and the corn have comparative advantages; rice, corn, soybean and tuber crops all do not have the scale advantages; the wheat, millet and the potatoes have obvious efficiency advantages while rice, corn and soybean have relatively weak efficiency advantages; wheat and corn have comprehensive comparative advantages, while rich, millet, soy bean and potatoes do not have the comprehensive comparative advantages. Combining with the current specific situation of Henan Province, the general situation faced by the production of main grain crops in Henan Province is analyzed specifically. In the end, suggestions on adjusting the structure of the main grain crops are put forward.

Key words Main grain crops, Comparative advantage, China

Since the reform and opening-up, the agricultural development environment has experienced great changes with the boost of the internationalization and agricultural marketization. The most notable feature is that the competition of agricultural products has become increasingly fierce at both of the domestic market and overseas market. As a disadvantaged industry, Chinese agriculture has to seek development in the competitive market as well.

In order to solve the problems of Chinese agriculture in the current stage, the profound research on the competitiveness of each kind of agricultural product at the domestic and foreign market is needed. The advantages and disadvantages of the products, which own the potential and practical competitiveness, should be analyzed. Through gearing the industrial structure, each industry will settle into rational road. In addition, the agricultural products, which meet the demands of the domestic and foreign markets, should be produced. Based on the problems of food and clothing which have been solved, Henan, as a granary agriculture, should lay stress on optimizing the structure of grain variety, gearing the layout of agricultural industries and boosting the regional layout of agricultural products, so as to increase farmers´ income. The efforts are of significant meaning on giving prominence to local features, displaying the advantages of resources, speeding up the construction of modern agriculture and probing into the road of developing Chinese agriculture and new villagers with the distinct Chinese characteristics.

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1 The status quo of the research both at home and abroad

In recent years, many scholars both at home and abroad have studied the comparative advantages of agricultural products. The Asian Development Bank[1], the Asia-Pacific Economic Cooperation (APEC)[2], the Food and Agriculture Organization of the United States (FAO)[3] and some other research organizations have applied the comparative advantages to conduct policy analysis. LU Feng(1995) closely connected the study on comparative advantages with the structure of Chinese food trade[4]. NIU Bao-jun(1997) applied the comparative advantage indices, the import and export price ratio and other methods, to analyze the comparative advantage. The results show[5] that the comparative advantage of grain crops has decreased and the comparative advantage is the result arising from comprehensive competition, and the comparative advantage is affected by a series of factors. LI Xiang-hong(1998) has conducted analysis of comparative advantage on Chinese grain by using the domestic resource cost coefficient[6]. By using the comprehensive comparative index formed on the basis of the yield and scale, KONG Ling-cong[7], calculated and analyzed the comparative advantages of the six major crops in each city of Anhui Province. Besides, by using the comparative advantage theory, DENG Ping[8], calculated and analyzed the comparative advantage index of the products, which came from the industries covering the farming, forestry, animal husbandry, and fishery, of Jiangxi Province from 2000 to 2003. In addition, WU Kai[9], conducted comparative advantage analysis on the food crops of China.

Through studying, Huxing[10] holds that comparative ad-

vantage determines the regional distribution of production, as well as trade structure and trade direction under the open domestic and overseas market. Based on the comparative advantage theory, HU Yanjun[11] conducted empirical analysis on the comparative advantage tendency of main agricultural products in Shanxi Province by applying the comparative advantage index. Furthermore, by using the comprehensive comparative advantage index, ZHANG Jiao-fang[12], measured and analyzed the comparative advantage of the production region of main agricultural products by using comprehensive advantage index. Moreover, based on the analysis of boosting the strategic significance of the distribution of advantageous agricultural products, TENG Cai-yuan[13], put forward the guiding ideology, basic principles and developmental goals for boosting the layout of the advantageous agricultural product distribution in Sichuan Province.

As a big agranary province, the aggregate yield of Henan Province has realized the yield increasing successively for six years, and the field ranks first in China successively for ten years. Moreover, the amount of grain per capita has broken through 500 kg, which not only guarantees enough food for nearly 0.1 billion people throughout the province, but also exports 15bilion kilogram food and finished products. Henan has made great contribution to the food safety of China. Based on the relevant data, I conduct the comparative advantage analysis on the main grain crops of Henan Province from 2000 to 2006, and the countermeasures are put forward through combining with the concrete analysis of situation faced by the production of main grain crops in Henan Province, so as to guide and push forward the optimization of agricultural production in China.

2 Data source and research method

2.1 Data source The data mainly comes from the *China Agriculture Yearbook* (2000 –2006) and *Henan Agriculture Yearbook* (2000 –2006). In the paper, the average number of the seven years from 2000 to 2006 is employed to reflect the index of each item.

2.2 Research method Based on comparative advantage theory, the revised comprehensive comparative advantage and the relevant data from 2000 to 2006, then the scale comparative advantage indices, the efficiency comparative advantage indices and the comprehensive comparative advantage indices are measured. And then, according to the measured results and the status quo of each region, the rational suggestions on gearing the scale of planting of main grain crops in each area of Henan Province are proposed.

2.2.1 The scale advantage index (P_{ij}). The scale advantage index refers to the ratio of the area of a certain crop in a certain period to the total area of the crop in the study area and the ratio of the high-level area in a certain period to another area.

The index fully presents the centralization degree and production scale concerning the production of agricultural products, and it is the result arising from the mutual effects of market demand, natural endowment, farming system and other factors. Its computing formula is:

$$P_{ij} = \frac{S_{ij}}{S_i} \Big/ \frac{S_j}{S} \quad (1)$$

In the formula, P_{ij} in the scale advantage index of the j crop in the i area; S_{ij} is the sown acreage of j crop in i area; S_i is the sown acreage of the researching crop in i area; $P_{ij} > 1$ means the sown acreage of j kind crop in high-level area; s refers to the total sown acreage of the researching crop in high-level area. ,indicates that comparing with the average level of the high-level area, production of such crop has the scale advantage. While, P_{ij}, indicates that the crop in the area have scale disadvantage. In summary, the smaller the P_{ij} value, the clearer the scale disadvantage.

2.2.2 The efficiency advantage index (C_{ij}). The efficiency advantage index refers to the ratio of the per unit yield level of a certain crop of a fixed area in a certain period to the average per unit yield level of the researching crop in the study area, and to that in the area of high level.

The index shows that the nature endowment (light, heat, water) determines the comparative advantage showed by the land production efficiency. Besides, the index is the comprehensive exemplification of the input of various kinds of materials and advancement of science and technology. Its computing formula is:

$$C_{ij} = \frac{Y_{ij}}{Y_i} \Big/ \frac{Y_j}{Y} \quad (2)$$

In the formula, C_{ij} refers to the efficiency advantage index of j crop in i area; Y_{ij} refers to the per unit of j crop in i area; Y_i shows the average yield per unit of the i area; Y_j means the per unit yield of j crop in high-level area; Y means the average per unit yield of the researching crop in high-level area. $C_{ij} > 1$, shows that comparing with the average level of the high-level area, the crops in the area has efficiency advantage, while $C_{ij} < 1$, illustrates that the crop in the area has the efficiency disadvantage. It can be seen that the smaller the value, the clearer the efficiency disadvantage will be.

2.3 The comprehensive comparative advantage index (CCA_{ij}) The comprehensive comparative advantage index combines the scale, efficiency and other factors of the j crop in i area, its computing formula is:

$$CCA_{ij} = \sqrt{P_{ij} \times C_{ij}} \quad (3)$$

CCA_{ij} integrates the factors like scale and efficiency, CCA_{ij}, indicates that the j crop in i area has production comparative advantage. The bigger the CCA_{ij} value, the strong the comparative advantage will be.

The above mentioned scale advantage index, efficiency advantage index and the comprehensive advantage, only the comprehensive advantage index can reflect the all-around advantage situations of different crops of each region.

3 The production tendency of main grain crops of Henan Province

3.1 The changing trend of farming pattern of the main grain crops in Henan Province From Table 1 and Table 2, it can be seen that the proportion of the grain crops in the farming pattern decreases annually. The proportion of the nation has

decreased from 69.4% to 67.2%, and the proportion of Henan Province has decreased from 68.7% to 65.6%.

Table 1 The proportion of the farming pattern of the nationwide main grain crops from 2000 to 2006 %

Year	Farming pattern	Grain crops	Rice	Wheat	Corn	Millet	Soy bean	Tuber crops
2000	100	69.4	19.2	17.1	14.8	0.8	6.0	6.7
2001	100	68.1	18.5	15.8	15.6	0.7	6.1	6.6
2002	100	67.2	18.2	15.5	15.9	0.7	5.6	6.4
2003	100	65.2	17.4	14.4	15.8	0.7	6.1	6.4
2004	100	66.2	18.5	14.1	16.6	0.6	6.2	6.2
2005	100	67.1	18.6	14.7	17.0	0.5	6.2	6.1
2006	100	67.2	18.7	14.6	17.2	0.6	5.9	6.3
Average	100	67.2	18.4	15.2	16.1	0.7	6.0	6.4

Note: Data are from *Chinese Agricultural Yearbook.*

Table 2 The proportion of farming pattern of main grain crops in Henan Province from 2000 to 2006 %

Year	Farming pattern	Grain crops	Rice	Wheat	Corn	Millet	Soy bean	Tuber crops
2000	100	68.7	3.5	37.5	16.8	0.6	4.3	4.6
2001	100	67.2	3.2	36.6	16.8	0.5	4.3	4.4
2002	100	67.2	3.5	36.3	17.4	0.4	4	4.1
2003	100	65.2	3.7	35.1	17.4	0.4	3.7	3.4
2004	100	65	3.7	35.2	17.5	0.3	3.8	3.2
2005	100	65.7	3.7	35.6	18	0.3	3.8	3.2
2006	100	65.6	4.2	35.3	18.2	0.3	3.6	2.9
Average	100	66.4	3.6	35.9	17.4	0.4	3.9	3.7

Note: Data are from *Chinese Agricultural Yearbook.*

Among the grain crops, the proportion of wheat and rice in China has decreased from 19.2% and 17.1% in 2000 to 18.7% and 14.6% in 2006 respectively; the proportion of rice in Henan Province has increased from 3.5% in 2000 to 4,2% in 2006, while the proportion of wheat has decreased from 37.5% in 2000 to 35.3% in 2006; the proportion of corn has increased annually in the proportion of farming pattern of the country and Henan Province and the proportion has increased from 14.8% 16.8% in 2000 to 17.2% and 18.2 % in 2006; the planting proportion of soy bean throughout the country has both ups and downs, but basically it keeps 6.0%, however the fluctuation of the proportion of wheat in Henan Province is great, for is decreased from 4.3% in 2000 to 3.6% in 2006; the planting proportion of millet in the China has decreased smoothly, but in Henan Province the it has decreased from 0.6% in 2000 to 0.3% in 2006; the proportion of tuber crops in the painting proportion of the whole nation and in Henan Province has decreased, and the proportion has decreased from 6.7% and 4.6% in 2000 to 6.3% and 2.6% in 2006 respectively.

3.2 The changes of sown acreage of main grain crops in Henan Province It can be seen from Table 3 that the sown acreage of main grain crops in Henan Province has increased steadily, which increased from 9 029 600 hm^2 to 9 303 100 hm^2 from 2000 to 2006. Among the main grain crops, the rice, wheat and corn show the ascending trend, which has increased from the 459 600 hm^2, 492 230 hm^2 and 22 013 hm^2 in 2000 to 602 600 hm^2, 5 006 700 hm^2 and 2 579 000 hm^2 in 2006. However, the nationwide sown acreage of rice and wheat has decreased from 29 961 900 hm^2 and 26 653 300 hm^2 in 2000 to 29 294 800 hm^2 and 22 961 600 hm^2 in 2006; the sown acreage proportion of millet, soy bean and tuber crops both in the nation and in Henan Province, showed the descending trend. From nationwide point of view, the sown acreage of millet, soy bean and tuber crops has decreased from 1 250 000 hm^2, 9 307 000 hm^2 and 10 539 000 hm^2 in 2000 to 865 400 hm^2, 9 280 100 hm^2 and 9 928 900 hm^2 in 2006, among them, the sown acreage of soy bean has greater fluctuation; the sown acreage of millet, soybean and tuber crops in Henan Province has decreased from 803 000, 565 000 and 603 000 in 2000 to 48 900, 516 400 and 413 200 in 2006.

Table 3 the sown acreage of main grain crops in Henan Province from 2000 to 2006 $\times 10^4$ hm^2

Year	Farming pattern		Grain crops		Rice		Wheat	
	The nation	Henan Province	The nation	Henan Province	The nation	Henan Province	The nation	Henan Province
2000	156 299.8	13 136.9	108 462.7	9 029.6	29 961.9	459.6	26 653.3	4 922.3
2001	155 707.9	13 127.7	106 080.0	8 822.8	28 812.5	415.9	24 664.0	4 801.6
2002	154 635.5	13 359.8	103 891.0	8 975.1	28 201.3	469.4	23 908.4	4 855.7
2003	152 415.0	13 684.4	99 410.0	8 923.3	26 507.9	503.0	21 997.1	4 804.6
2004	153 552.5	13 805.7	101 606.0	8 970.1	28 378.7	508.5	21 626.1	4 856.0
2005	155 487.7	13 922.6	104 279.0	9 153.4	28 847.4	511.1	22 792.4	4 962.7
2006	157 020.6	14 185.6	105 489.0	9 303.1	29 294.8	602.6	22 961.6	5 006.7
Average	155 017.0	13 603.2	10 4174.0	9 025.3	28 572.1	495.7	23 514.7	4 887.1

Year	Corn		Millet		Soy bean		Tuber crops	
	The nation	Henan Province	The nation	Henan Province	The nation	Henan Province	The nation	Henan Province
2000	23 056.3	2 201.3	1 250.0	80.3	9 307.0	565.0	10 539.0	603.0
2001	24 282.2	2 200.0	1 148.2	65.9	9 481.8	563.5	10 216.8	572.7
2002	24 633.9	2 319.9	1 139.7	58.5	8 719.5	528.0	9 881.7	552.3
2003	24 068.2	2 386.7	1 024.4	58.0	9 312.8	503.4	9 701.6	552.3
2004	25 446.0	2 420.0	915.6	39.3	9 589.0	522.5	9 456.8	437.6
2005	26 358.1	2 508.3	849.2	41.3	9 590.9	533.6	9 503.0	443.0
2006	26 970.8	2 579.0	865.4	48.9	9 280.1	516.3	9 928.9	413.2
Average	24 973.6	2 373.6	1 027.5	56.0	9 325.9	533.2	9 889.7	498.8

3.3 The changes of yield per unit area of main grain crops in Henan Province It can be seen from Table 4 that the yield per unit area of grain crops fluctuates from 2000 to 2006 both in the whole country and in Henan Province, but the

overall trend is increasing and the yield per unit area of grain crops has ascended from 4 261 kg/hm^2 and 4 542 kg/km^2 in 2000 to 4 716 kg/km^2 and 5 385 kg/km^2 in 2006; among the main grain crops, the yield per unit area of rice, wheat, corn and millet shows the ascending trend both in the whole country and in Henan Province; the yield per unit area of soybean shows rising trend in the whole country, but in Henan it shows the decreasing trend; the yield per unit area of tuber crops shows the ascending trend in around the country, but in Henan Province it is in descending trend; the yield per unit area of tuber crops shows descending trend both in the whole country and in Henan Province.

Table 4 The per unit area yield of main grain crops in Henan Province kg/hm^2

Year	Grain crops		Rice		Wheat		Corn		Millet		Soy bean		Tuber crops	
	The nation	Henan Province	The nation	Henan Province	The nation	Henan Province	The nation	Henan Province	The nation	Henan Province	The nation	Henan Province	The nation	Henan Province
2000	4 261	4 542	6 272	6 936	3 738	3 738	4 598	4 883	1 700	978	1 650	2 055	3 495	4 845
2001	4 267	4 670	6 163	4 874	3 806	4 789	4 699	5 234	1 712	2 215	1 625	1 909	3 488	4 762
2002	4 399	4 691	6 189	7 169	3 776	4 630	4 925	5 129	1 909	2 239	1 893	1 852	3 710	4 833
2003	4 332	4 000	6 061	4 775	3 932	4 771	4 813	3 211	1 895	1 534	1 653	1 126	3 621	3 011
2004	4 621	4 749	6 311	7 044	4 252	5 109	5 120	4 339	1 979	2 545	1 815	1 981	3 762	4 662
2005	4 642	5 006	6 260	7 040	4 275	5 194	5 287	5 175	2 102	2 712	1 705	2 089	3 649	5 194
2006	4 716	5 385	6 232	7 081	4 550	5 638	5 394	5 603	1 985	1 963	1 721	1 257	3 430	4 753
Average	4 463	4 720	6 213	6 417	4 047	4 953	4 977	4 796	1 897	2 027	1 723	1 753	3 594	4 580

In 2003, Henan Province was hit by long-lasting continual rain, low temperature, inadequate sunshine and serious natural disasters such as hailstone and floods in part of Henan Province, so the yield of grain crops in the whole province was sharply decreased except the slight increase of yield per unit area of wheat, and the overall yield has decreased by 15.2%. Besides, the total yield of corn, which accounts for 58.1% of the total sown acreage of autumn grain in Henan Province, has attained to 7.663 million ton, 4.235 million ton less than 11.898 million ton in 2002, and the decreasing amplitude has reach 35.6%, which is the biggest reduction in production and deceasing amplitude in the history of Henan Province. The aggregate yield of other grain crops such as rice, has come to 2.401 7 million, the decreasing amplitude has attained to 28.6%; the aggregate yield of soybean was 0.566 7 million ton with the decreasing amplitude of 42.1%.

4 Comparative advantage analysis of main grain crops in Henan Province

4.1 The scale advantage analysis of main grain crops in Henan Province The scale advantage of main grain crops in Henan Province can be calculated according to Table 3 and formula (1). From the Table 5, it can be seen that among the main grain crops in Henan Province, only the wheat and rice have the scale advantage, and the scale advantage indices are 2.40 and 1.10 respectively.

The scale advantage indices of other main grain crops, such as rice, millet, soybean and tuber crops are all smaller than 1, which indicates that they do not have scale advantage. Rice in particular, for its advantage index is 0.20, which do not has a little bit of scale advantage. Therefore, in the development strategy of the sown acreage of main grain crops in Henan Province, the sown acreage of wheat and corn should be guaranteed.

4.2 The efficiency advantage analysis of main grain crops in Henan Province The efficiency advantage of main grain crops in Henan Province can be calculated. It can be seen from Table 6 that the efficiency advantage of main grain crops in Henan Province is high. Among them, the wheat, millet and tuber crops have obvious efficiency advantages, and their efficiency advantage indices are 1.16, 1.00 and 1.20 respectively.

Table 5 The scale advantage indices of grain crops in Henan Province from 2000 to 2006

Year	Rice	Wheat	Corn	Millet	Soy bean	Tuber crops
2000	0.18	2.22	1.15	0.77	0.73	0.69
2001	0.17	2.34	1.09	0.69	0.71	0.67
2002	0.19	2.35	1.09	0.59	0.7	0.65
2003	0.21	2.43	1.1	0.63	0.6	0.54
2004	0.20	2.54	1.08	0.49	0.62	0.52
2005	0.20	2.48	1.08	0.55	0.63	0.53
2006	0.23	2.47	1.08	0.64	0.63	0.47
Average	0.20	2.40	1.10	0.62	0.66	0.58

Table 6 The efficiency advantage indices of main grain crops in Henan Province from 2000 to 2006

Year	Rice	Wheat	Corn	Millet	Soy bean	Tuber crops
2000	1.04	1.14	1.00	0.54	1.17	1.30
2001	0.72	1.15	1.02	1.18	1.07	1.25
2002	1.09	1.15	0.98	1.10	0.92	1.22
2003	0.85	1.31	0.72	0.88	0.74	0.90
2004	1.09	1.17	0.82	1.25	1.06	1.21
2005	1.04	1.13	0.91	1.20	1.14	1.32
2006	1.00	1.09	0.91	0.87	0.64	1.21
Average	0.98	1.16	0.91	1.00	0.96	1.20

Other grain crops like rice, corn and soybean have relatively weak efficiency advantage, for their efficiency advantage indices are 0.98, 0.91 and 0.96 respectively. Consequently, in the development strategy of per unit yield of main grain crops in Henan Province, efficient measures should be taken to enhance the per unit yield of rice, corn and soy bean and the other main grain crops without reducing the per unit yield of wheat,

millet and tuber crops.

4.3 The comprehensive advantage analysis of main grain crops in Henan Province The efficiency advantage of main grain crops in Henan Province (Table7) can be calculated according to Table 5, Table 6 and formula (3). It can be seen from Table 7 that, among the main grain crops in Henan Province, only the comprehensive advantage index of wheat reach 1.67 with obvious comprehensive advantage. The following one is the corn, whose comprehensive index is 0.99. But the low index is caused by the weather in 2003, which led to the decrease of per unit area yield, thus the production of corn in Henan Province also has comprehensive advantage basically. The indices of other main grain crops are all lower than 1, which indicates that they do not have comprehensive advantage.

Table 7 The comprehensive advantage indices of main grain crops in Henan Province from 2000 to 2006

Year	Rice	Wheat	Corn	Millet	Soy bean	Tuber crops
2000	0.44	1.59	1.07	0.65	0.92	0.95
2001	0.35	1.64	1.05	0.90	0.88	0.92
2002	0.46	1.64	1.03	0.81	0.80	0.89
2003	0.42	1.79	0.89	0.74	0.67	0.70
2004	0.47	1.72	0.94	0.78	0.81	0.80
2005	0.46	1.67	0.99	0.81	0.85	0.84
2006	0.48	1.64	0.99	0.74	0.64	0.76
Average	0.44	1.67	0.99	0.78	0.80	0.84

5 Conclusions and discussions

5.1 Conclusions The comparative advantage of crop yield reflects the natural endowment of the grain production characteristics of each city to a certain extent; the scale comparative advantage reflects the regional food specialization level of and the market position feature to some degree and the comprehensive comparative advantage mirrors the comprehensive competitiveness of various kinds of grain crops at some point. According to the comprehensive comparative advantage to adjust the production location of main grain crops in each city of Henan Province is beneficial to improving the all-around abilities of grain production of the whole province. Besides, the comprehensive comparative advantage index can be use as theory evidence for gearing the farming system of regional grain crops.

5.1.1 The scale comparative advantage of main grain crops. According to the scale comparative advantage indices of six kinds of grain crops from 2000 to 2006, the scale comparative advantage descending from wheat, corn, soybean, millet, tuber crops to rice successively. Their scale comparative advantage indices are 2.40, 1.10, 0.66, 0.62, 0.58 and 0.20 respectively.

5.1.2 The efficiency comparative advantage of main grain crops. According to the efficiency comparative advantage indices of the six kinds of grain crops from 2000 to 2006, the efficiency comparative advantage descending from tuber crops, wheat, millet, rice, soybean to corn successively. Their efficiency comparative advantage indices are 1.20, 1.16, 1.00, 0.98, 0.96 and 0.91 respectively.

5.1.3 The comprehensive comparative advantage of main grain crops. In the light of the comprehensive comparative advantage indices of the six kinds of crops from 2000 to 2006, the comprehensive comparative advantage of main grain crops in Henan Province ranking descending from wheat, corn, tuber crops, soybean, millet and rice successively. Their comprehensive advantage indices are 1.67, 0.99, 0.84, 0.80, 0.78 and 0.44 respectively.

5.1.4 The adjustment of the production structure of main grain crops in Henan Province. The adjustment of grain crops should be based on the target of improving agricultural quality, enhancing agricultural comparative interests, raising the income of farmers and elevating the international comparativeness of agricultural products In addition, not only the varieties and quality structure of agricultural products need adjusting, but also the regional farming system and the layout of agricultural products. So as to form the specialized economic region with distinctive features; to develop the economic belt facing different markets and display the comparative advantage of different regions.

5.2 Discussions The suggestions used for adjusting the contracture of grain crops are put forward as follows: enlarging the production of advantageous crops; stabilizing and modulating the production of equipollent crops and abandoning disadvantageous crops. The production of main grain crops such as wheat, corn and the like should be developed further according to the natural conditions and their comparative advantages. Henan Province should establish the industrial layout dominated by high-quality wheat and high-quality corn. Besides, the production of wheat and corn should be improved in order to enhance the regional production capability. The production of grain crops such as rice and millet should be shrank appropriately. Furthermore, the development planning of crop farming and the adjustment of industrial structure should be expedited and positively meet the needs of consumers and great efforts are needed to improve the competitiveness of agricultural products.

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coal resources supply in China. High-energy-consumption industry accounts for a big proportion, such as thermal power generation and so on. The *EFI* of it can reach up to 1.10 hm^2 every ten thousand yuan, which ranks the first in China. From the view of regional distribution, the *EFI* decreases gradually from west to east. As the level of regional economy is improved, the *EFI* has the downward trend. The quantity of population shows notable impact on *EFI*. The per capita GDP does not show the nagative relationship with *EFI*, which can not prove the existence of Environmental Kuznets Curve.

2.3 STIRPAT model analysis of energy footprint Using STIRPAT model, we analyze the interaction between *EEF* and economic development. Then we use the least squares method to realize the model fitting. The fitting results can be seen in Table 2.

Table 2 Fitting results of the model

Variable	Regression coefficient	Standard error	*t* value
ln*a*	0.254	0.422	0.603
ln*P*	0.742	0.113	6.578
ln*A*	0.090	0.474	1.920
$(\ln A)^2$	−0.340	0.271	−1.256

From Table 2, we know that the regression coefficient of human population is 0.742, which has a significant impact on energy footprint. It demonstrates that under the situation of the same other conditions, the population increases by 1% will result in 0.742% increase of total *EEF*; the regression coefficient of per capita GDP is 0.090, which indicates that the relationship between per capita GDP and *EEF* is not negative, and when *EEF* increases by 0.09%, the per capita GDP increases by 1%. Although the quadratic term regression coefficient of per capita GDP is negative(−0.340),the significance probability of coefficient *t* is 1.920, bigger than 0.05, which demonstrates that there is no significant difference between its coefficient and 0. Therefore, it cannot prove the existence of Environmental Kuznets Curve, indicating that solving energy problem cannot merely depend on economic development.

3 Conclusions

3.1 From the regional distribution, we can draw the conclusion that provinces with higher *EEF* mainly concentrate in the Middle Eastern China which have a developed industry, such as Shandong, Hebei, Liaoning Province and so on. However, provinces with lower *EEF* mainly concentrate in the Western China which have a relatively poor economy, such as Ningxia, Qinghai Province and so on. These results are in accordance with the area distribution of China's economic development level.

3.2 From the regional distribution, we can draw the conclusion that provinces with higher *EEF* mainly concentrate in the Middle Eastern China, which have a developed industry, such as Shandong, Hebei, Liaoning Province and so on. However, provinces with lower *EEF* mainly concentrate in the Western China. The *EFI* decreases gradually from west to east. As the level of regional economy is improved, the *EFI* has the downward trend.

3.3 From STIRPAT model, we can come to the conclusion that the quantity of population has a significant impact on *EEF*, while the relationship between per capita GDP and *EEF* is not negative, which cannot prove the existence of Environmental Kuznets Curve.

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