Panel Data Based Dynamic Evaluation of Agricultural Resource Utilization Efficiency: A Case Study of Hebei Province

Yajuan TIAN[1*], **Li ZHEN**[2]

1. College of Economics of Hebei University, Baoding 071002, China; 2. Hebei Software Institute, Baoding 071000, China

Abstract Resource utilization efficiency is one of important factors influencing modern agricultural development. This paper evaluates agricultural resource utilization efficiency of Hebei Province in the Eleventh Five-Year Plan period by dynamic comprehensive evaluation method. Evaluation results indicate that regional disparity in agricultural resource utilization efficiency is significant, and the disparity is increasing year by year.

Key words Agricultural resource utilization efficiency, Panel Data, Dynamic comprehensive evaluation, Gap widening, Hebei Province

1 Introduction

The panel-data-based dynamic comprehensive evaluation, as a new branch of comprehensive evaluation field, is the further development and extension of static comprehensive evaluation method. Compared with the static comprehensive evaluation method, the dynamic comprehensive evaluation method adds measurement for time dimension of evaluation objects, so the evaluation conclusion is more general. We observed and surveyed resource utilization efficiency of agricultural production in Hebei Province in the Eleventh Five-Year Plan period by dynamic evaluation method, and analyzed the reasonableness and effectiveness of use of agricultural resources, to provide basis for understanding modern agricultural production level and development potential and making relevant agricultural policies and development plans.

2 Research method

Vertical and horizontal scatter degree method[1] is a widely applied method in dynamic comprehensive evaluation. The determination of weight factor is based on the difference reflected in panel data, to scatter degree as far as possible and to do benefit to ranking.

Assume that there are m evaluation indicators (maximization indicators through consistent processing and non-dimensional disposal) of n evaluation objects. We established panel data sheet $\{x_{ij}^{t_k}\}$ $(i=1, 2, L, n; j=1, 2, L, m; k=1, 2, L, p)$ for $n\times m\times p$ dimension in the time t_1, t_2, t_p. For the time $t_k(k=1, 2, L, p)$, take the comprehensive evaluation function of the i-th object as:

$$y_i(t_k)=\sum_{j=1}^{m}\omega_j x_{ij},\ k=1, 2, L, p;\ i=1, 2, L, n;\ j=1, 2, L, m \quad (1)$$

where t_k signifies the time, ω_j refers to the weight factors, and $x_{ij}^{t_k}$ stands for the j-th indicator value of the i-th evaluation object in the time t_k. Based on standardization processing of original data, the total dispersion square sum of $y_i(t_k)$ can be denoted as:

$$\sigma=\sum_{k=1}^{p}\sum_{i=1}^{m}[y_i(t_k)-\bar{y}]^2=\sum_{k=1}^{p}\sum_{i=1}^{m}[y_i(t_k)]^2=\sum_{k=1}^{p}[\omega^T H_k\omega]=\omega^T H\omega \quad (2)$$

where $\omega=(\omega_1, \omega_2, L, \omega_m)^T$, and H is symmetrical matrix of $m\times m$ order.

ω can be obtained through the following non-linear planning.

$$\begin{cases}\max \omega^T H\omega \\ s.t.\quad \omega>0 \\ \quad \|\omega\|=1\end{cases} \quad (3)$$

The solution of this non-linear planning maximizes σ^2 value.

With advantages such as simple principle, obvious visual significance, transparent evaluation process, and objective and comparable evaluation results, this evaluation method is deemed as a realistic and feasible dynamic comprehensive evaluation method.

3 Evaluation of resource utilization efficiency of Hebei Province

3.1 Selection of evaluation indicators To effectively survey agricultural resource utilization efficiency of different regions, we divided agricultural resources into land resource, water resource, biological resource, human resource and technological resource[2], and selected corresponding indicators to measure the agricultural resource utilization efficiency. Indicators and their explanation[3-4] are listed in Table 1.

3.2 Evaluation procedure Indicators listed in Table 1 are maximized. In combination with relevant data in *Rural Statistical Yearbook of Hebei Province* (2007 – 2011), we calculated the standardized data by the non-linear planning MATLAB listed in formula (3). Through normalization, we obtained the weight factor of vertical and horizontal scatter degree method:

$$\omega=(0.23, 0.27, 0.21, 0.10, 0.20)^T$$

Bringing the standardized data and weight factor into the formula (1), we obtained the resource utilization efficiency evaluation value $y_i(t_k)$ of every region. Obviously, the higher this val-

Received: December 20, 2012 Accepted: January 31, 2013
Supported by Hebei Province Philosophy and Social Science Planning Project in 2011 (201102002).
* Corresponding author. E-mail: tianyajuan@126.com

ue, the better it is. Since the data is standardized, the $y_i(t_k)$ value will fluctuate around the average value 0. In other words, the resource utilization efficiency of regions with $y_i(t_k) > 0$ is above the average value. Taking the average of $y_i(t_k)$, we can obtain the average evaluation value $\bar{y}_i$ of every region in the Eleventh Five-Year Plan period.

$$\bar{y}_i = \frac{1}{5}\sum_{t_k=2006}^{2010} y_i(t_k),\ i=1,2,L,n;\ t_k=2006, 2007, 2008, 2009, 2010$$

$y_i(t_k)$ and $\bar{y}_I$ and their ranking can be found in Table 2.

Table 1 Indicator system for evaluating the agricultural resource utilization efficiency

Resource type	Evaluation indicators	Indicator explanation
Land resource	Land productivity	Per unit area yield of grain
Water resource	Output ratio of water resource	Per unit area yield of grain/Agricultural water supply of unit area
Biological resource	Fertilizer output rate	Per unit area yield of grain / converted pure application amount of unit fertilizer
Human resource	Labor productivity	Gross Agricultural Product / labor input
Technological resource	Contribution rate of agricultural science and technology	Rate of progress in agricultural science and technology / growth rate of Gross Agricultural Product

Table 2 Evaluation value of agricultural resource utilization efficiency in Hebei Province

	2006	2007	2008	2009	2010	Average score	Ranking
Cangzhou	1.04	1.18	1.82	2.75	3.08	1.97	1
Handan	1.33	1.43	1.83	2.12	2.68	1.88	2
Shijiazhuang	0.55	0.43	0.86	1.12	1.17	0.83	3
Hengshui	0.43	0.39	0.34	0.87	1.03	0.61	4
Langfang	-0.23	-0.06	0.27	0.66	1.05	0.34	5
Xingtai	-0.17	0.05	0.24	0.27	0.34	0.15	6
Baoding	-0.64	-0.72	-0.37	-0.07	0.57	-0.25	7
Tangshan	-1.14	-0.78	-0.31	0.25	0.37	-0.32	8
Qinhuangdao	-1.3	-1.38	-1.01	-0.72	-0.75	-1.03	9
Chengde	-1.62	-1.84	-1.51	-0.67	-2.37	-1.6	10
Zhangjiakou	-2.67	-2.15	-3.31	-1.61	-3.12	-2.57	11

3.3 Result analysis The average score in Table 2 indicates that there is significant difference in agricultural resource utilization efficiency in every region of Hebei Province. With reference to these scores, we can classify these regions with three groups: the low efficiency group, the medium efficiency group, and the high efficiency group. The low efficiency group has the score below the average level (below zero), including Zhangjiakou, Chengde, Qinhuangdao, Tangshan, and Baoding, mainly distributed in middle and northern regions of Hebei Province; the medium efficiency group has the score slightly higher than the average level (in the range of 0 and 1), including Shijiazhuang, Hengshui, Langfang, and Xingtai, mainly distributed in southern regions of Hebei Province; the high efficiency group has the score above the average level (above 1), including Cangzhou and Handan, separately situated in easternmost and southernmost regions of Hebei Province.

(1) From horizontal perspective, the high efficiency group has outstanding performance in resource utilization. In Cangzhou region, it is manifested as high efficient utilization of water resource and biological resource in agricultural production. However, in Handan region, it is shown in utilization of technological resource and human resource. From the perspective of vertical development, the resource utilization efficiency of these two regions is gradually rising, and faster than the average growth speed of the same period.

(2) In the medium efficiency group, the resource utilization efficiency of most regions is at the average level. Vertically speaking, apart from the human resource utilization efficiency, the variation in utilization efficiency of other resources also keeps average speed, and the difference with the high efficiency group is increasingly widening.

(3) In the low efficiency group, five regions have the value below 0, but there is significant difference, and it can be divided into two types. The gap between Baoding and Tangshan is small. From the perspective of vertical development, the utilization efficiency of all types of resources has significant growth. In 2010, the average score turns to positive value, and regions become progressive regions in the low efficiency group. From comparison, it is found that there is a big gap between Qinhuangdao, Chengde, and Zhangjiakou and the average level. From the perspective of vertical development, the growth rate of resource utilization efficiency is slower than the average level, and the gap with other regions is also widening, thus they are classified as backward regions in the low efficiency group.

4 Conclusions

Based on the panel data, we analyzed agricultural resource utilization efficiency of regions in Hebei Province in the Eleventh Five-Year Plan period by the dynamic comprehensive evaluation method. Horizontal comparison indicates that there are significant differences in agricultural production efficiency of regions in Hebei Province. According to the average evaluation score, they can be divided into high efficiency group, medium efficiency group and low efficiency group. The middle and low efficiency group regions take on the characteristic of centralized distribution. In combination with variation in time data of indicators, there is significant improvement of every region in the human resource utilization

(To page 62)

cessibility are mainly concentrated in the western city groups of Liaoning Province and eastern Liaoning's Dandong.

Table 1 Comparison of accessibility between nodes of rural recreational tourism destination in Liaoning Province Unit: km

Node	Accessibility index	
	Scores	Sequence
Shenyang	162.85	1
Dalian	164.72	2
Liaoyang	166.86	3
Anshan	170.86	4
Panjin	172.93	5
Yingkou	182.43	6
Benxi	190.57	7
Jinzhou	202.57	8
Fushun	205.29	9
Tieling	219.36	10
Fuxin	232.36	11
Huludao	243.15	12
Dandong	274.86	13
Chaoyang	304.99	14
Average	206.70	

5 Conclusions and recommendations

This paper uses geographical mathematical method to analyze the travel spatial structure of rural recreational tourism destinations from aggregation degree of spatial distribution, the balance of spatial distribution, spatial connection and spatial accessibility. The results show that the spatial distribution of tourism destinations shows the gathering distribution pattern, and the evenness of the distribution is very low, displaying strong neighboring positive effect; the accessibility of traffic network is high, and basically the dense tourist traffic network is formed; the nodes with the best accessibility are mainly concentrated in the city groups of central Liaoning and the southern regions of Liaoning, while the nodes with poor accessibility are mainly concentrated in the city groups of western Liaoning and the eastern regions of Liaoning.

Based on these conclusions, we put forward the following recommendations:

(1) Strengthening the tourism traffic network construction of the western city groups in Liaoning Province, to improve transportation accessibility. First, it is necessary to perfect the transportation network within the city groups, and focus on accelerating the highway transportation construction of Fuxin – Chaoyang, Fuxin – Huludao, Chaoyang – Huludao, Jinzhou – Chaoyang, Jinzhou – Huludao; at the same time, it is necessary to vigorously improve the existing road grade, and gradually expand the provincial highways within the city groups into national highways, to comprehensively improve the connectivity and accessibility within the city groups. Second, it is necessary to improve the transportation network linked with the outside, to improve the accessibility; speeding up the Liaoning Binhai Avenue building and the transport network construction between Shenyang and the city groups in Liaoning Province; at the same time, it is necessary to take effective measures to improve the operation capacity of Beijing – Shenyang railway network and expressway network, to strengthen contact and communication with the outside.

(2) Strengthening the tourism contact center status of Shenyang and Dalian, and constructing the gathering areas of rural recreational tourism destinations. As the central city in the city groups of Liaoning Province, Shenyang plays a significant role in leading the development of other cities within the group, but the leading role to the city groups in Liaoning Province needs to be further strengthened; Dalian is regarded as the central city in the coastal economic zone of Liaoning Province, and its leading role has not yet been fully apparent. Thus, on the basis of improving the inter-regional travel transportation network accessibility, the two central cities should take effective measures to enhance their strength in tourism resources, tourism products, tourism market and tourism technology, so that the gathering capability and leading role of the central tourist cities are more prominent.

References

[1] XIAO GM. Analysis and optimizing on the spatial structure of pearl rever delta region[J]. Economic Geography, 2009, 29(6): 1036 – 1041. (in Chinese).
[2] XIE ZH, WU BH. Tourism spatial structure of resources – based attractions in China[J]. Scientia Geographica Sinica, 2008, 28(6): 748 – 753. (in Chinese).
[3] WU BH, TANG ZY. A study on spatial structure of national 4a grade tourism attractions in China[J]. Human Geography, 2003, 18(1): 275 – 279. (in Chinese).
[4] CHEN SL, ZHANG HQ, MU GS. Analysis on tourism transportation network of capitals of the six central provinces based on their tourism cooperation[J]. Journal of Henan University: Natural Science Edition, 2009, 39(3): 1 – 6. (in Chinese).
[5] JIANG YH. On tourism spatial structure in Liaoning Province[D]. Dalian: Liaoning Normal University, 2009. (in Chinese).
[6] WANG DG. Spatial structure of tourism resources in the tourism region of Hulun Buir – Aershan[J]. Arid Land Geography, 2008, 31(3): 456 – 463. (in Chinese).
[7] WU JF, BAO HS. Research on the spatial network model of tourism system [J]. Scientia Geographica Sinica, 2002, 22(1): 96 – 101. (in Chinese).
[8] ZHANG JH, ZHAO Y. Analysis on the spatial structure of tourism resources in the south of Anhui Province[J]. Geography and Geo – Information Science, 2004, 20(1): 99 – 103. (in Chinese).

(From page 59)

efficiency. Generally speaking, the high efficiency group has faster growth, while the backward regions in low efficiency group grow slowly, forming the widening difference in the development trend of resource utilization efficiency in Hebei Province.

References

[1] GUO YJ, PAN JM, CAO ZQ. Dynamic comprehensive evaluation method supported by multi – dimensional time series[J]. Journal of Northeastern University(Natural Science), 2001, 22(4): 464 – 467. (in Chinese).
[2] SONG W, CHEN BM, CHEN XW, *et al*. Reinterpretation and evaluation for use efficiency of agricultural resources: A case study of Changshu in Jiangsu Province and Taihe in Jiangxi Province[J]. Progress in Geography, 2010, 29(3): 319 – 326. (in Chinese).
[3] LIU XW. Resource utilization efficiency of grain production: Taking Ansai County and Changshu City as example[D]. Beijing: CAS, 2005. (in Chinese).
[4] XU Y. A study on the evaluation index system of agricultural resources effective utility[J]. Progress in Geography, 2001, 20(3): 240 – 246. (in Chinese).