Research Article
A Data Envelopment Analysis based Research on the Economic Efficiency of Primary industry in Hohhot, Baotou and Ordos

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Abstract: In this study, we analyze a data envelopment based research on the economic efficiency of primary industry in hohhot, baotou and ordos. The triangle Area of Hohhot, Baotou and Ordos leads the whole economic development in Inner Mongolia. The economic efficiency of primary industry of the county-level units in Hohhot. Baotou and Ordos is evaluated by the data envelopment analysis in this study. It is concluded that the metric value can show objectively the development of the primary industry in each county-level unit.

Keywords: Primary industry, Data Envelopment Analysis, efficiency, metric value

INTRODUCTION

The primary industry is a sector of national economy classified by "three time industry classification". And in China, it refers to agriculture, animal husbandry, forestry and fishing. Data Envelopment Analysis (DEA), put forward by Charnes *et al*. (1978), is a method of multi-input-output analysis based on Relative Efficiency. After over 30 years of development, there are lots of derived and dedicated DEA models. The DEA method shows its important place and become one of the powerful tools for system analysis. The C2R model, which introduced by Charnes *et al*. (1978) and the BC2 model, introduced by Banker *et al*. (1984), are the basic models of DEA method. The triangle Area of Hohhot, Baotou and Ordos is the core economic unit in Inner Mongolia. In this study, the economic efficiency of primary industry of the county-level units in Hohhot, Baotou and Ordos is evaluated by BC2 model with output only. Banker *et al*. (1984) study some models for estimating technical and scale inefficiencies in data envelopment analysis. Charnes *et al*. (1978) have a research of the measuring the efficiency of decision making unit. He (1995) analyze the data envelopment analysis with output (o r input) only and its application. Li-Chang *et al*. (2004) study the efficiency evaluation on equity finance of listed companies on basis of dea. Deng-Yue (2005) studies the empirical research on the commercial banks' efficiency based on data envelopment analysis.

In this study, we analyze a data envelopment based research on the economic efficiency of primary industry in hohhot, baotou and ordos. The triangle Area of Hohhot, Baotou and Ordos leads the whole economic development in Inner Mongolia. The economic efficiency of primary industry of the county-level units in Hohhot. Baotou and Ordos is evaluated by the data envelopment analysis in this study. It is concluded that the metric value can show objectively the development of the primary industry in each county-level unit.

THE SELECTION OF DECISION MAKING UNIT (DMU) AND THE BC[2] MODEL WITH OUTPUT ONLY

There are many types of industrial economic efficiency evaluation indexes. According to the goals, objects and data availability of the evaluation, labor productivity, output rate of material consumption and energy consumption rate are evaluated here.

Assuming LR_j, WR_j, RR_j represent the labor productivity, output rate of material consumption, Output rate of energy consumption in a period of time of a certain area respectively, then the vector (LR_j, WR_j, RR_j) indicates the status of the economic benefits of the region in that period. And according to the result, we establish the BC2 model with output only shown as follows:

Table 1: Data of economic efficiency of primary industry of the county-level units in Hohhot, baotou and ordos in 2010

County-level unit	Xincheng District	Huimin district	Yuquan district
LR	0.816	0.841	1.579
WR	112.857	28.993	19.282
RR	12.911	2.209	20.651
County-level unit	Saihan district	Tumotezuo banner	Tuoketuo county
LR	3.573	2.605	2.653
WR	16.212	11.81	4.505
RR	23.075	27.762	26.371
County-level unit	Helingeer County	Qingshuihe county	Wuchuan county
LR	2.687	1.232	0.725
WR	18.831	3.904	2.886
RR	33.476	48.405	18.017
County-level unit	WuchuanCounty	Kundulun district	Qingshan district
LR	3.881	5.63	6.057
WR	12.202	16.943	65.705
RR	18.334	9.151	16.672
County-level unit	Jiuyuan District	Shiguai District	Tumoteyou banner
LR	3.764	0.907	3.047
WR	16.908	6.348	8.298
RR	13.584	12.981	40.92
County-level unit	Guyang county	Daerhanma-omingan union banner	Dongsheng district
LR	1.91	4.968	1.939
WR	6.733	13.107	14.258
RR	14.273	52.012	13.866
County-level unit	Dalate banner	Hungeer banner	Etuokeqian banner
LR	3.361	2.087	4.124
WR	5.775	7.67	6.578
RR	9.888	18.886	24.939
County –level unit	Etuoke banner	Hangjin Banner	Wushen Banner
LR	2.431	2.437	3.054
WR	11.734	5.471	13.237
RR	65.385	24.361	10.789
County-level unit	Yijinhuoluo banner		
LR	1.463		
WR	12.564		
RR	7.483		

LR. WR. RR in the table represent labor productivity, materials consumption and energy consumption rate respectively. The data sources are form Inner Mongolia Statistical Yearbook 2011
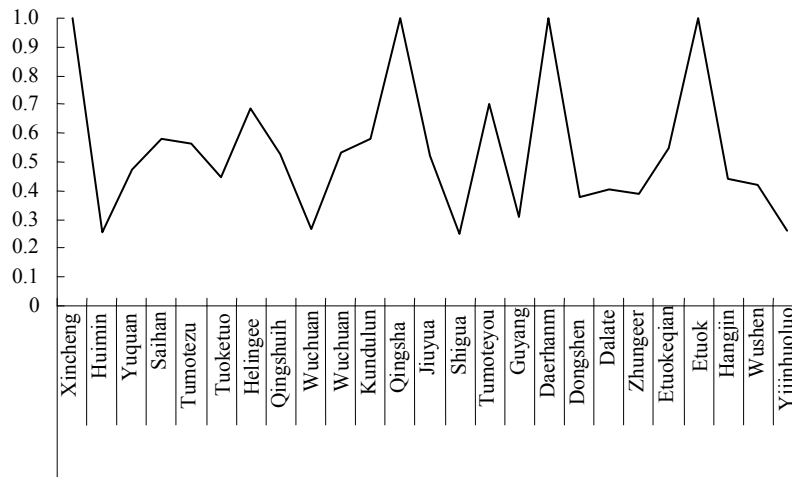

Fig. 1: Metric value of each country-level unit

$$(E\text{-}DEA)\begin{cases} \max[\theta + \varepsilon(s_1^+ + s_2^+ + s_3^+)] \\ \text{s.t.} \sum_{j=1}^{n} LR_j \cdot \lambda_j - s_1^+ = \theta \cdot LR_{j_0} \\ \sum_{j=1}^{n} WR_j \cdot \lambda_j - s_1^+ = \theta \cdot WR_{j_0} \\ \sum_{j=1}^{n} RR_j \cdot \lambda_j - s_1^+ = \theta \cdot RR_{j_0} \\ \sum_{j=1}^{n} \lambda_j = 1 \\ s_1^+, s_2^+, s_3^+ \geqq 0, \lambda_j \geqq 0, j = 1, 2, ..., n \end{cases}$$

Among them:

$LR_j = Y_j/L_j$
$WR_j = Y_j/Cs_j$
$RR_j = Y_j/R_j$

And Y_j, L_j, Cs_j, R_j represent the GDP, labor number, materials consumption and energy consumption of primary industry respectively.

Table 2: Efficiency value of each county-level unit

County-level unit	Xincheng district	Huimin district	Yuquan district
θ	1	3.2878	2.1227
S^+_1	0	0	0
S^+_2	0	0	0
S^+_3	0	7.0467	0
County-level unit	Saihan district	Tumotezuo banner	Tuoketuo county
θ	1.5337	1.7744	1.8959
S^+_1	0	0	0
S^+_2	12.9803	0	7.5655
S^+_3	0	0	0
County-level unit	Helingeer county	Qingshuihe county	Wuchuan county
θ	1.4623	1.3508	3.5807
S^+_1	0	0.7666	0
S^+_2	0	6.4607	1.4897
S^+_3	0	0	0
County-level unit	Wuchuan county	Kundulun District	Qingshan district
θ	1.4779	1.0758	1
S^+_1	0	0	0
S^+_2	32.1579	47.477	0
S^+_3	0	6.8272	0
County-level unit	Jiuyuan district	Shiguai district	Tumote-you banner
θ	1.571	3.988	1.3723
S^+_1	0	0	0
S^+_2	32.1957	0	1.294
S^+_3	0	0	0
County-level unit	Guyang county	Daerhanma-omingan union banner	Dong-sheng district
θ	2.7962	1	2.6619
S^+_1	0	0	0
S^+_2	12.2923	0	0
S^+_3	0	0	0
County -levelunit	Dalate banner	Zhungeer banner	Etuoke-qian banner
θ	1.7925	2.4618	1.343
S^+_1	0	0	0
S^+_2	53.7876	2.4382	31.8355
S^+_3	0	0	0
County-level unit	Etuoke banner	Hangjin banner	Wushen banner
θ	1	2.0612	1.9403
S^+_1	0	0	0
S^+_2	0	4.5078	33.6787
S^+_3	0	0	0
County-level unit	Yijinhuoluo banner		
θ	3.8424		
S^+_1	0		
S^+_2	0		
S^+_3	0		

Table 3: Metric value of each county-level unit

County-level unit	Xincheng District	Huimin district	Yuquan district
E_j	1	0.2542	0.4711
County-level unit	Saihan district	Tumotezuo banner	Tuoketuo County
E_j	0.5775	0.5636	0.4449
County-level unit	Helingeer county	Qingshuihe county	Wuchuan County
E_j	0.6839	0.5266	0.2675
County-level unit	Wuchuan county	Kundulun district	Qingshan district
E_j	0.5321	0.5788	1
County-level unit	Jiuyuan district	Shiguai district	Tumoteyou Banner
E_j	0.5203	0.2508	0.7039
County-level unit	Guyang county	Daerhan- maomingan union banner	Dongsheng district
	0.3105	1	0.3757
County-level unit	Dalate banner	Zhungeer banner	Etuokeqian banner
E_j	0.4019	0.3907	0.5503
County –level unit	Etuoke banner	Hangjin banner	Wushen banner
E_j	1	0.439	0.4179
County-level unit	Yijinhuo-luo banner		
E_j	0.2603		

Theorem 1: If λ^0, s^{+0}_1, s^{+0}_2, s^{+0}_3, θ^0 are the Optimal solution of (E-DEA), then the DMU$_{j0}$ is DEA efficient if:

$$\theta^0 = 1, (s^{+0}_1, s^{+0}_2, s^{+0}_3) = 0$$

Theorem 2: If decision making unit (LR$_j$, WR$_j$, RR$_j$) are DEA inefficient, the optimal solution of (E-DEA) are λ^0, s^{+0}, θ^0, then $(\theta^0 LR_{j0}+s^{+0}_1$, $\theta^0 WR_{j0}+s^{+0}_2$, $\theta RR_{j0}+s^{+0}_3)$ is DEA efficient.

Definition 1: For the DMU's effective value:

$$(LR_{j0}, WR_{j0}, RR_{j0})$$

Let

$$E_{j0} = 1/3 \ (LR_{j0}/ \ \theta^0 LR_{j0}+s^{+0}_1+ \ WR_{j0}/\theta^0 \ WR_{j0}+ \ s^{+0}_2+ RR_{j0}/\theta^0 RR_{j0}+s^{+0}_3),$$ then call the E_{j0} is the metric value of decision making unit (LR$_{j0}$, WR$_{j0}$, RR$_{j0}$).

Theorem 3: When (LR$_{j0}$, WR$_{j0}$, RR$_{j0}$) are DEA efficient, $E_{j0} = 1$. When (LR$_{j0}$, WR$_{j0}$, RR$_{j0}$) are DEA inefficient, $0 < E_{j0} < 1$.

ANALYSIS OF THE ECONOMIC EFFICIENCY OF PRIMARY INDUSTRY IN HOHHOT, BAOTOU AND ORDOS

The economic efficiency data of primary industry of the county-level units in Hohhot, Baotou and Ordos in 2010 was calculated using the economic efficiency indicators above. Look at the Table 1.

Summarizing the data into the program with lingo 9.0, we can get the efficiency value of each county unit as shown in Table 2.

The metric value of each county-level unit is shown in Table 3.

Figure 1 the difference between the metric values of each county-level unit

CONCLUSION

We can find out the development of primary industry of Hohhot, Baotou and Ordos from the metric value. The metric value of Huimin District, Yuquan District, Tuoketuo County, Wuchuan County, GuyangCounty, Shiguai District, Dongsheng District, Dalate Banner, Zhungeer Banner, Hangjin Banner, Wushen Banner, Yijinhuoluo Banner is lower than 0.5. There are three reasons for the lower value. Firstly, there is less land but much labor engaged in primary industry, as Huimin District and Yuquan District. Secondly, some areas like Tuoketuo County, Wuchuan County and Guyang County are dependent mainly on consumption of resources and energy. Thirdly, some areas as Shiguai District, Dongsheng District, Dalate Banner, Zhungeer Banner, Hangjin Banner, Wushen Banner, Yijinhuoluo Banner are Resource-based regions, their primary industries are not developed enough or they have less room for development.

The metric value of Saihan District, Tumotezuo Banner, Helingeer County, Qingshuihe County, Donghe District, Kundulun District, Jiuyuan District, Tumoteyou Banner and Etuokeqian Banner is between 0.5 and 1. These areas are relatively dependent on the consumption of resources and energy.

The metric value of Xincheng District, Daerhanma-omingan Union Banner, Etuoke Banner is 1, it means these area's economic efficiency of primary industries is DEA efficient. Because these areas were weighted at animal husbandry industry and the industries are not dependent on the resources and energy and thus the output rate of material consumption and energy consumption rate are higher than those of other areas.

We can find out that the unbalanced development of primary industry of county-level units in Hohhot, Baotou and Ordos is limited by the region's natural and geographical conditions. Some area's primary industry makes concessions for their overall development and thus causes low efficiency.

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