Study on Technology Efficiency of China Rape Production: Based on Measurement and Analysis of Panel Data in 14 Main Production Provinces of Rape during 2006 -2013

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Abstract Panel data of rape input and output in 14 rape production provinces of China during 2006 -2013 were measured by data envelopment analysis (DEA). According to the measurement results, average scores of technology efficiency in Henan, Hunan, Jiangsu, Sichuan, Zhejiang and Chongqing were all 1, while average scores of Anhui, Qinghai, Yunnan, Gansu and Shaanxi were lower, which ranked latter in the 14 provinces. To further study the reason for lower pure technology efficiency in the 5 provinces, relaxation amount and relaxation degree of factor input in the year when its pure technology efficiency was not 1 were collected, thereby obtaining surplus situation of factor input in rape production of the 5 provinces. Moreover, the phenomenon that redundancy degree of farm manure surpassed that of chemical fertilizer, and material cost per mu was excess largely in the 5 provinces was explained, and some suggestions were proposed.

Key words DEA, Rape, Technology efficiency

1 Introduction

Rapeseed oil has been the tradition oil of Chinese residents living, which has a very important strategic position in supply of domestic edible vegetable oil. From 2002 to now, the proportion of rapeseed oil in domestic edible vegetable oil supply is next only to soybean oil. But in China, soybean industry has been threatened by growing crises, and more than 70% of soybean oil materials are from import. How to guarantee the yield of domestic rapeseed becomes an important problem involving national food security strategy.

Rape seed is the material of squeezing rapeseed oil. Therefore, it should increase rape yield to realize safe supply of rapeseed oil. Generally speaking, there are two kinds of channels increasing crop yield: one is increasing input amount of factor, and the other is improving production efficiency of factor. However, considering the limitation of agricultural production resources and eco-environment problems brought by continuous increase of some agricultural production factors (such as chemical fertilizer and pesticide), continuous growth of output is bound to more rely on the promotion of utilization efficiency of production factor.

Rolf Fare *et al.* pointed out that the improvement of full-element production efficiency could be realized by two channels: technology progress and technology efficiency. Technology progress indicates outward movement of whole production frontier (the maximum output curve realized under certain technology level), while technology efficiency indicates approach of input-output point to production frontier. When it is closer to the production frontier, it illustrates technology efficiency is higher. It tells us that we should value the improvement of technology efficiency when wants to improve full-factor production efficiency under certain technology. Therefore, it has very important actual significance to study technology efficiency in rape production and its variation situation.

Data envelopment analysis (DEA) is the highly favored method of measuring technology efficiency in recent years, and there are more researches about the measurement of technology efficiency by the method at home and abroad. In agricultural production field, research direction is roughly divided into two kinds: one is studying specific grain type[1-2], and the other is measuring technology efficiency of agricultural production based on macro level[3-4]. When using DEA method, panel or section data are used to measure in most of researches, and treatment object in some researches is time series data. For the problem if could use DEA to treat time series, the pro party thinks that time could be as decision making unit(DMU), and its specific principle is as same as analysis of cross section data; opposite party thinks that considering DEA analysis method implicates the supposition of not existing technology progress, it is unreasonable to treat time series data by DEA method. The span of time series data generally grows to more than ten years. If supposing that there is no technology progress during the period, it is obviously contrary to the reality.

There are many problems to be discussed when using DEA method to treat time series data. In this paper, empirical analysis on production technology efficiency of rape industry was conducted by using panel data, and the reason for no production efficiency during research period was analyzed from the angle of factor input.

2 Test methods

Technology efficiency connects with production frontier. There are two kinds of methods measuring technology efficiency: one is stochastic frontier production function method, and the other is DEA. The limitation of stochastic frontier production function

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method is setting specific function form, and different function forms may obtain different conclusions. In contrast, DEA is a kind of non-parameter estimation method using linear planning to construct non-parameter piecewise curved surface (or frontier) and calculating the efficiency of each decision-making unit to frontier surface (namely relative efficiency). Therefore, it needs not clearly setting a specific function form. Additionally, DEA could avoid the measurement problems, such as simultaneous equation set bias and equation setting error. Therefore, the method is popular in nowadays. Considering many good characteristics of DEA method, we used the method to measure technology efficiency of rape production.

In DEA, based on two kinds of suppositions (CRS and VRS), it could be divided into two models (CCR and BCC). The supposition of CRS is suitable for the situation that all companies operate in the best scale, but imperfect competition and government regulation generally exist in actual world. Therefore, the supposition of VRS is general.

Based on different analysis perspectives, DEA model could be divided into two kinds: input oriented and output oriented. Input oriented type indicates planning problem of input minimization under certain output level; output oriented type indicates planning problem of output maximization under certain input level. Said from the essence, input oriented type and output oriented type are used to solve the same problem from the different angles, and their final conclusions are consistent. Because that input amount is basic variable of decision making, and input amount is easier to be controlled than output amount, VRS of DEA model of input oriented type was used in the research.

3 Measurement on technology efficiency of rape production in China

3.1 Variable selection In this paper, technology efficiency of rape production in each province was measured based on the perspectives of mu input and output in rape plantation process. The input of rape production mainly contained material and labor force inputs. Therefore, in the selection of input variables, five indexes were used to measure material input: seed cost per mu, chemical fertilizer cost per mu, farm manure cost per mu, pesticide cost per mu and other materials costs per mu (animal force cost, machinery cost and discharge-irrigation cost), while input of labor force was measured by labor quantity per mu. In the selection of output variable, rape yield per mu was selected to measure output, and the meaning of variable was actual number of rape product per mu.

3.2 Data source Basic data in the research were mainly from the *Compilation on Benefit and Cost of Agricultural Product in Whole Country*(2007 – 2014). Comprehensively considering availability and continuity of data and number requirement of DEA method on decision-making unit and input-output variable, data of 14 main rape production provinces were selected as analysis sample.

3.3 Data treatment To exclude the influence of price change in different years, the input seed cost per mu, chemical fertilizer cost per mu, farm manure cost per mu, pesticide cost per mu and other costs per mu in rape production process of each province all used agricultural production material price index of each province over the years to adjust into the prices in 2006. In addition, DEA method requires that input and output need meeting same-amplitude expansion. Pearson correlation analysis of the converted data was conducted, and correlation coefficients among items were all positive, illustrating that data corresponded with the requirement.

4 Measurement results

The software was used to measure technology efficiency of rape production in 14 rape production provinces, and average scores of technology efficiency in each rape production province during 2006 – 2013 were shown as Table 1.

Table 1 Average scoring situation of technology efficiency in each province

Province	Score								Mean	Ranking
	2006	2007	2008	2009	2010	2011	2012	2013		
Henan	1	1	1	1	1	1	1	1	1	1
Hunan	1	1	1	1	1	1	1	1	1	1
Jiangsu	1	1	1	1	1	1	1	1	1	1
Sichuan	1	1	1	1	1	1	1	1	1	1
Zhejiang	1	1	1	1	1	1	1	1	1	1
Chongqing	1	1	1	1	1	1	1	1	1	1
Hubei	1	1	1	1	0.945913	1	1	0.977013	0.990366	7
Jiangxi	1	1	1	1	1	0.936054	0.976951	1	0.989126	8
Guizhou	1	1	1	0.981378	1	0.933774	1	0.935234	0.981298	9
Anhui	1	0.886949	0.968892	1	1	0.950909	0.986876	1	0.974203	10
Qinghai	1	0.843691	0.823394	1	1	1	1	1	0.958386	11
Yunnan	0.889309	1	1	0.955916	0.864725	0.944209	1	1	0.956770	12
Gansu	1	0.955492	1	0.944463	1	1	0.814757	0.880377	0.949386	13
Shaanxi	1	1	0.937305	1	0.925392	0.815397	0.724368	0.816923	0.902423	14

By combining region factor, Table 1 was analyzed. It was found that in 14 rape production provinces, the province with higher production technology efficiency was mainly in east and center regions, while Qinghai, Yunnan, Gansu and Shaanxi that average score ranked last were all in west region.

Table 2 Summary of input relaxation amount and degree in 5 provinces

Province	Year	Labor quantity per mu		Seed cost per mu		Chemical fertilizer cost per mu	
		S1	Relaxation amount//%	S2	Relaxation amount//%	S3	Relaxation amount//%
Anhui	2007	0	0	0	0	0	0
	2008	0	0	0	0	0	0
	2011	-0.157604	2.171	0	0	0	0
	2012	0	0	0	0	0	0
Qinghai	2007	-3.053042	18.425	-1.915465	15.949	0	0
	2008	-4.206665	27.513	-1.276475	11.246	0	0
Yunnan	2006	-0.157622	1.210	0	0	0	0
	2009	-3.681647	29.981	0	0	-8.10835	12.695
	2010	-0.180953	1.635	0	0	0	0
	2011	0	0	0	0	-18.865920	28.045
Gansu	2007	0	0	0	0	-5.459928	8.645
	2009	0	0	0	0	-28.008000	35.137
	2012	0	0	0	0	0	0
	2013	0	0	0	0	0	0
Shaanxi	2008	-7.153334	42.327	0	0	-14.8116	22.25
	2010	-1.100359	8.975	0	0	0	0
	2011	-2.720388	21.370	0	0	0	0
	2012	0	0	-2.975458	15.954	-12.65052	17.237
	2013	-0.745348	5.791	-7.812851	35.114	-17.99227	23.498

Province	Year	Farm manure cost per mu		Pesticide cost per mu		Other cost per mu	
		S4	Relaxation amount//%	S5	Relaxation amount//%	S6	Relaxation amount//%
Anhui	2007	-0.824527	10.268	0	0	-8.93506	23.700
	2008	0	0	0	0	-3.854011	9.933
	2011	0	0	-0.664489	7.700	-9.218967	23.222
	2012	-2.971137	40.812	-0.766442	8.119	-7.394822	19.328
Qinghai	2007	0	0	-1.419367	18.975	-16.542990	34.025
	2008	0	0	0	0	-17.990740	37.125
Yunnan	2006	-6.374081	39.813	-0.397521	4.015	-5.331044	16.701
	2009	-12.079890	60.279	-3.407354	32.328	-8.304912	22.041
	2010	-6.275381	39.818	-1.715498	16.479	0	0
	2011	-2.399054	18.846	-7.187195	56.282	-27.88882	60.826
Gansu	2007	-0.656575	5.386	0	0	-22.79949	40.859
	2009	-16.375110	64.878	0	0	-35.43402	49.454
	2012	-3.019640	32.158	-0.928060	8.368	-21.91932	33.041
	2013	-4.111457	40.190	-0.392182	4.392	-22.21378	27.327
Shaanxi	2008	0	0	0	0	-3.406966	7.195
	2010	0	0	-1.064215	16.003	-9.493480	15.838
	2011	0	0	-1.577676	20.331	-7.658977	13.390
	2012	0	0	0	0	0	0
	2013	0	0	0	0	0	0

Table 1 also displayed that technology efficiency of rape production in Henan, Hunan, Jiangsu, Sichuan, Zhejiang and Chongqing always maintained at higher level, and their efficiency scores over the years were all 1. Hubei and Jiangxi all maintained efficient rape production during 2006 - 2009, but technology efficiency declined after 2009. Overall, the two provinces realized efficient production, and annual average efficiency score maintained over 0.98. Average scores of technology efficiency of rape production in Anhui, Qinghai, Yunnan, Gansu and Shaanxi were lower, and the score (0.90) of technology efficiency in Shaanxi farther lagged than that (0.95) of Gansu, which ranked last in 14 rape production provinces. For the situation that pure technology effi-

ciency of rape production in Anhui, Qinghai, Yunnan, Gansu and Shaanxi was not high, input redundancy analysis was conducted in the 5 provinces, which aimed to explain the situation from surplus angle of factor input.

Table 2 collected relaxation amount and degree of factor input in the year when technology efficiency scores of rape productions in Anhui, Qinghai, Yunnan, Gansu and Shaanxi were not 1.

In rape production of Anhui Province in 2007, 2008, 2011 and 2012, the inputs that redundancy degree ranked top three were other cost per mu, farm manure cost per mu and pesticide cost per mu. Among them, redundancy degrees of other cost per mu were all higher than 19% in 2007, 2011 and 2012. Input surplus of farm manure cost per mu reached 2.97 yuan in 2012, which was about 41% of farm manure input cost per mu in the year.

The inputs that redundancy degree ranked top three in Qinghai in 2007 and 2008 were other cost per mu, labor quantity per mu and seed cost per. Among them, redundancy degree of other cost per mu was more than 30% in the two years, which farther exceeded the redundancy degrees of other two costs.

One of influence factors for pure technology efficiency of rape production in Yunnan was excessive farm manure input per mu. Seen from Table 2, farm manure costs per mu in Yunnan Province in 2006, 2009, 2010 and 2011 had a greater degree of surplus, and the proportions of surplus value to input volume were respectively 39.8%, 60.3%, 39.8% and 18.8%. Besides input surplus of farm manure, excessive inputs of pesticide cost per mu and other cost per mu also deserved attention. Redundancy degree of pesticide cost per mu always ranked second in 2008, 2010 and 2011, while other cost per mu in 2011 exceeded 27.89 yuan, with 61% of excess degree.

Scores of pure technology efficiency of rape production in Gansu in 2012 and 2013 were only 0.8148 and 0.8803, which were significantly lower mean levels of 14 provinces in the two years(0.9645 in 2012 and 0.9721 in 2013). In the two years, input redundancy degrees of farm manure cost per mu and other cost per mu were the most serious, and their excess ratios were all more than 30%, which was far higher than pesticide cost per mu that redundancy degree rank third(surplus rates in the two years were all below than 10%).

During 2006 – 2013, annual average score of production technology efficiency in Shaanxi Province ranked last in 14 rape production provinces. Seen from Table 1, ranking situation of Shaanxi Province wasn't so bad. It was because that pure technology efficiency in 2011, 2012 and 2013 was too lower, which pulled low whole level. In 2011, excess labor force, pesticide and other cost inputs was main reason for lower pure technology efficiency. In 2012 and 2013, it was caused by excessive utilizations of seed and chemical fertilizer.

Seen from Table 2, in rape production of the five provinces, compared with chemical fertilizer, redundancy degree of farm manure was larger. Large excess of material cost per mu has become significant factor affecting pure technology efficiency of rape production in the 5 provinces. The two phenomena seemed ordinary, but deep meaning could be induced by analysis. According to the understanding, accompanied with "urbanization" of rural life, the amount of farm manure accumulated in routine life decreased increasingly, and the utilization of chemical fertilizer was convenient and efficient. Therefore, farmer tended to use a lot of chemical fertilizer in planting process of rape, and the application proportion of farm manure was very little. Under the condition, redundancy situation of chemical fertilizer input in rape production should be serious. But the measured data during 2006 – 2013 showed that surplus degree of farm manure was more serious in some provinces. The phenomenon could be explained from the below angles[5].

Because the price of chemical fertilizer in recent years was higher, many farmers largely increased accumulation and utilization amounts of farm manure to decline production cost of rape. But seen from total fertilization amounts of farm manure per mu in the 5 provinces, redundance of farm manure was not caused by that utilization amount exceeded the best application amount per mu, and lower utilization efficiency of farm manure was essential reason for the phenomenon.

After understanding essential reason, for input surplus of farm manure, we should not simply give the suggestion of "decreasing input amount of farm manure". Farm manure could not only ease soil compaction problem brought by excessive utilization of chemical fertilizer but also protect environment and promote the development of green agriculture. Therefore, it is essential countermeasure to improve composting technology and utilization rate of farm manure.

The reason for redundance of material cost per mu was difficult to be analyzed, and it was because that other material costs included machinery cost, animal force cost, fuel cost and agricultural membrane cost. Considering the proportion of each expense in total expenses, the reason for large excess of material cost per mu in the 5 provinces was analyzed from machinery cost and animal force cost.

At present, sowing and harvest of rape in China had the below problems: mechanization level in most of regions was lower, and animal force still occupied dominant position. Although purchase cost of machine tool was expensive, with the increasing of application area, the cost per mu declined fast. Although animal force cost was cheap, efficiency was extremely low. When ploughing the same farmland area, its cost may greatly surpass utilization cost of machinery, and time consumption was several times of machinery. Seen from the angle, large redundancy of material cost per mu in the 5 provinces could be explained as below.

In sowing and harvest processes of rape, due to high mechanization levels in Hubei, Hunan and Jiangsu, the utilization proportion of animal force declined, and it largely saved material cost per mu. But compared with these provinces of production frontier, the five provinces all had some problems that mechanization level was limited, and production mainly depended on animal force. Therefore, production efficiency was relatively lower, and material cost per mu was relatively higher.

Based on the angle, to decrease redundance of material cost per mu and improve pure technology efficiency of rape production in the five provinces, it should commence from cultivating rape va-

riety suitable for mechanization harvest and improving mechanization level. It could not only decrease cost, improve production efficiency and increase benefit but also decrease labor capacity of rape production to a great extent and liberate rural productivity.

5 Conclusions

In this paper, using DEA method, technology efficiency of rape production in 14 rape production provinces of China during 2006 - 2013 was measured, and the research conclusions were as below.

(1) According to average scores of technology efficiency during 2006 - 2013, in 14 rape production provinces, the province with higher production technology efficiency was mostly in east and center regions, while Qinghai, Yunnan, Gansu and Shaanxi that average scores ranked last were all in west region.

(2) In Anhui, Qinghai, Yunnan, Gansu and Shaanxi, surplus degree of farm manure was more than that of chemical fertilizer, and redundancy of other material cost was serious. By combining actual situation, the reason was analyzed, and the explanation was as below:the price of chemical fertilizer in recent years was higher, which caused that farmer increased greatly utilization amount of farm manure and decreased utilization amount of chemical fertilizer. Therefore, surplus situation of chemical fertilizer was eased. Due to immature composting technology of farm manure in the five provinces, utilization rate of farm manure was low. So, although input of farm manure was more, when using actually, its contribution to yield increase was limited. Under the existing yield, the situation of input surplus of farm manure appeared in the five provinces with higher utilization rate of farm manure.

(3) There were many reasons causing redundance of other material cost per mu. If analyzing from mechanical cost and animal force cost with the maximum proportion, it could be explained that in rape production process of the five provinces, mechanization degree was relative lower, and it mainly used animal force to sow and reap. Efficiency of animal force was extremely low, and the cost per mu was even higher than mechanical cost. Under the existing yield level, compared with other provinces with higher mechanization degrees, the item cost had redundance in the five provinces.

(4) According to the reasons for surpluses of farm manure cost per mu and other material cost per mu, the solving measures were proposed. Firstly, developing composting technology of farm manure and improving utilization rate of farm manure. Secondly, according to the situation of each province, cultivating rape variety suitable for mechanized sowing and reaping, scale planting, and replacing traditional animal force ploughing by efficient machine, thereby further improving production efficiency of rape.

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ers, government sectors should correctly understand their role of managers and supervisors in community participation in rural tourism. At the same time of guiding community residents to participate in tourism development, government should work out corresponding supervision and management measures, impose certain punishment on farmers who overcharge tourists, protect characteristic and typical rural tourism resources, protect historical sites and remains with historical value, avoid artificial destruction to ecological environment and traditional culture, and sternly punish tourists who willfully damage public facilities in tourist areas and those who damage local ecological environment.

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