Study on Exogenous Influencing Factors of Green Agricultural Plant Production Technology

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Abstract. The production efficiency of green agricultural plants is an important criterion for assessing the economic and environmental benefits of agricultural production. The improvement of production efficiency of green agricultural products is an important issue that needs to be studied urgently. Based on the survey data of farm agricultural product cultivation in Shandong province, the non-parametric DEA (data envelopment analysis) method and model were used as the basis for discussion. A green agricultural grain production benefit evaluation standard system was established. The Malmquist coefficient analysis method was used comprehensively, and the DEAP2.1 software was used to study the changes of green crop production efficiency, and the key factors affecting the change of green agricultural production efficiency were analysed through comprehensive index evaluation.

1. Introduction

The family farms mainly engaged in green agricultural plant production was chosen as the research object in this study. From the perspective of exogenous environment, this study tried to answer the exogenous factors and countermeasures affecting the production and operation efficiency of agricultural products under the diversified business background.

The mainstream agricultural scale economics school believed that because the large farms had the advantages of science and technology, information and market, their production and operation efficiency tended to be higher and the farms were higher. In empirical research, Tanure¹ proposed a novel conceptual macro model that used systems of agricultural and livestock production environments as information systems to support decision-making processes. The model could cover all aspects of an agricultural production system. Latruffe² studied the differences in technical efficiency and productivity and technological gaps between dairy and cereals in the French and Hungarian farms between 2001 and 2007, the oil crop and protein (COP) industry. The results showed that French COP farms used their own technology to be more efficient than Hungarian farms. However, the rate of enabling technology at the Common Frontier Construction calculations indicated that Hungarian technology was more efficient in the dairy and COP industries. Picazo-Tadeo³ used data envelopment analysis to study agro-ecological benefits. The value of ecological benefits under the special stress level of agriculture and environment was the determinant of ecological benefits obtained by farmers.
operating in the agricultural system in Campos County, Spain. As a result of the impact of these policies, public spending on agricultural extension and farmer training might help to promote integration between agriculture and the environment.

However, due to the short time officially proposed by family farms in China, there were few results of empirical measurement of family farm management efficiency. In theory, scholars indirectly explained the operating efficiency of family farms by analysing the characteristics of farm operations and comparing them with other agricultural operators. Zhou et al. [4] selected large and medium-sized agricultural leading enterprises in 11 cities and municipalities in Jiangxi Province in 2010 as samples, and analysed the operational efficiency of agricultural leading enterprises by using the ultra-efficient DEA method. Zhu [6] believed that the lower limit of the moderate scale of family farms was the livelihood needs of family members, and the upper limit was the scale corresponding to the maximization of family members’ operating capacity.

In summary, in the evaluation of the efficiency of green agricultural plant production technology, the existing research sample size was small, the research of individual sample size and the research data were relatively old. Therefore, it was difficult to reflect the latest situation. Moreover, there were few studies on plant production techniques, which in turn affected the reliability of research conclusions.

2. Evaluation method and theoretical analysis

2.1. Evaluation method
This study used already known data to obtain a corresponding production frontier using the DEA model to measure the relatively useful way of planning units (DMUs) with multiple inputs and multiple outputs. Its application principle was to first apply the linear programming method to estimate the edge of production possibility, and then measure the relative efficiency of each decision unit, and finally judge whether it is in the frontier of producing the set of possible inputs and outputs according to the result. This method can plan different agricultural input and management methods according to the characteristics of different farmers, and objectively reflect the different production methods of different farmers.

2.2. Model description
(1) DEA-based BCC evaluation model. The input-oriented BCC model was selected in this study to evaluate the production efficiency of green agricultural family farms in Shandong Province.

There were n plan units in the set model, and each plan unit had m input categories and s output categories, and \( X_{ij} \) (\( X_{ij} > 0 \), \( i=1, 2, \ldots, m \)) represented the input of the jth plan unit to the i-th kind. \( Y_{jr} \) (\( Y_{jr} > 0 \), \( r=1, 2, \ldots, s \)) represents the input amount of the rth species by the jth plan unit, and was recorded as: \( X_j = (X_{ij}, \ldots, X_{mj})^T \), \( Y_j = (Y_{i1}, \ldots, Y_{is})^T \), among them \( X_j \) is the input amount of the jth plan unit, \( Y_j \) is the output amount of the jth plan unit.

\( \lambda_j \) is the combination coefficient of each unit, \( \varepsilon \) is the non-Archimedean endless small amount, \( \theta \) is the efficiency evaluation index, \( S^- \) and \( S^+ \) are the relaxation variables, and the following dual model is established:

\[
P_{bcc} : \max \left( \mu^T Y_o + \mu_o \right); W^T X_j - \mu^T Y_j - \mu_o \geq 0, j = 1,2,\ldots,n; W^T X_0 = 1;
\]

\[
W \geq 0, \mu \geq 0
\]

\[
D_{bcc} : \min\left\{ \theta - \varepsilon (e^T S^- + e^T S^+) \right\}; \sum_{j=1}^{n} X_j \lambda_j + S^- = \theta X_0; \sum_{j=1}^{n} Y_j \lambda_j - S^+ = Y_0; \sum_{j=1}^{n} \lambda_j = 1;
\]

\[
S^- \geq 0, S^+ \geq 0, \lambda \geq 0, j = 1,2,\ldots,n
\]
To solve the linear relationship above, whether the BCC model could be used to determine the usefulness of the decision-making unit were mainly the values of $\theta$, $S'$, and $S^*$. The following rules were used:

① If $\theta$ is set to 1 and the values of $S'$ and $S^*$ are both 0, then the unit of this decision is useful;
② If $\theta$ is set to 1 but any of $S'$ and $S^*$ is not 0, indicating that the unit of this decision is useful;
③ If the $\theta$ setting is less than 1, it means that the unit of this decision is useless, and the excess of the input and output can be analyzed according to this.

(2) A Malmquist evaluation model based on DEA. The DEA model has many characteristics in terms of evaluation efficiency. If the classic model of DEA is used to evaluate the production efficiency of planted family farms in Shandong Province, it can only use the cross-section data to compare the static efficiency of the decision-making unit horizontally, and it does not reflect the decision-making unit. There is a lack of vertical comparison benchmarks for efficiency changes over time. The Malmquist exponential method of the DEA model can effectively compensate for the shortcomings of the CCR model and the BCC model.

The definition of the Malmquist index is the analytical way that Caves et al. used the ratio between the Malmquist quantity criterion and the actual and maximum values of Shperhard to calculate the change in yield efficiency. Use $X_t, Y_t$ and $X_{t+1}, Y_{t+1}$ to represent the input and output of period $t$ and time $t+1$, respectively, and use $D_0'(X_t, Y_t)$ instead of time $t$, $D_0'(X_{t+1}, Y_{t+1})$ instead of time $t+1$ as the actual value and maximum output of the output vector into the reference period $t$. The ratio between values, Fare et al (1994) used the geometric mean of the technical Malmquist index for the two periods as the Malmquist index.

$$M_0(X_t, Y_t, X_{t+1}, Y_{t+1}) = \frac{D_0'(X_{t+1}, Y_{t+1})} {D_0'(X_t, Y_t)} \times \frac{D_0'(X_{t+1}, Y_{t+1})} {D_0'(X_t, Y_t)} \times \frac{D_0'(X_{t+1}, Y_{t+1})} {D_0'(X_t, Y_t)}$$

$$= D_0'(X_{t+1}, Y_{t+1}) \times D_0'(X_{t+1}, Y_{t+1}) \times D_0'(X_{t+1}, Y_{t+1})$$

$$= E(X_{t+1}, Y_{t+1}, X_t, Y_t) \times T(X_{t+1}, Y_{t+1}, X_t, Y_t)$$

Among them, $E(X_{t+1}, Y_{t+1}, X_t, Y_t)$ indicates technological efficiency progress, indicates technological progress, and technological efficiency progress can be divided into pure technical efficiency progress and scale efficiency progress. Changes in the agricultural productivity index include changes in the allocation, use, and scale of agricultural resource elements in each city; changes in the technology index include changes in the technical aspects of production in each city; the conversion of the purely technical efficiency index includes only the allocation of agricultural resources. Changes in the level of use; changes in scale efficiency indicators include changes in the scale of agricultural production. If $EC(CRS)>1$, it means that the agricultural production efficiency increases during $t$ and $t+1$; when $EC(CRS)=1$, it means that the agricultural production efficiency has not changed during this time; when $EC(CRS)<1$, This indicates that agricultural production efficiency has decreased during this period [7].

2.3. Evaluation of parameter indicators selection and data sources
(1) Selection of evaluation parameter indicators
The DEA method was applicable to the cumbersome system evaluation of multiple placement and multi-production, and belonged to the dimension that did not need to unify the various indicators. Combined with the actual production situation of agricultural products in the planting family farms in Shandong Province, after repeated optimization and adjustment, the data of input and output indicators of agricultural products produced by planting family farms were selected as DMU, and the data of each input and output index were taken from official statistics or surveys. According to the requirements of the indicator system, the following indicators were used as indicators of input (X) and output (Y).
output (Y): material and service costs per mu (X1); labor costs per acre (X2); total cost per acre (X3) per The amount of labor used per mu (X4); the amount of fertilizer per mu (X5); the wage of workers (X6); the net profit per mu (Y1); the output value per mu (Y2).

(2) Data source
This study was based on the research data of the innovation team, the research report of the relevant departments of the province, and the data of the National Crops and Costs Data Summary compiled by the Values Division of the National Development and Reform Commission, so as to accurately reflect and deeply analyse the family farms in Shandong province. The status quo and problems of economic development of fruit and vegetable industry, and prospects for the future, put forward relevant policy recommendations, and provided reference for government authorities and industries. According to the survey data of fruit and vegetable test stations, the data of production and output indicators of fruits and vegetables in family farms of each table and the percentage increase of production cost of plants in the previous year were calculated.

2.4. Analysis of calculation results
(1) Overall evaluation of comprehensive technical efficiency
As shown in Table 1, the BCC model and the DEA analysis software DEAP2.1 were used to empirically analyse the comprehensive technical benefits of the agricultural production of the planted family farms in various cities in Shandong.

Table 1. Production efficiency value of agricultural products of planted family farms in 13 cities of Shandong province

| area       | Comprehensive efficiency | Technical efficiency | Scale efficiency | Scale increase and decrease |
|------------|--------------------------|----------------------|-----------------|-----------------------------|
| Jinan      | 0.962                    | 0.998                | 0.985           | irs                         |
| Qingdao    | 0.955                    | 0.996                | 0.976           | drs                         |
| Zibo       | 0.975                    | 0.998                | 0.988           | irs                         |
| Zaozhuang  | 1                        | 1                    | 1               | --                          |
| Yantai     | 0.958                    | 0.998                | 0.951           | irs                         |
| Weifang    | 1                        | 1                    | 1               | --                          |
| Jining     | 0.988                    | 0.977                | 0.989           | irs                         |
| Taian      | 1                        | 1                    | 1               | --                          |
| Weihai     | 0.957                    | 0.998                | 0.951           | irs                         |
| Linyi      | 1                        | 1                    | 1               | --                          |
| Liaocheng  | 1                        | 1                    | 1               | --                          |
| Binzhou    | 0.967                    | 0.988                | 0.967           | drs                         |
| Heze       | 1                        | 1                    | 1               | --                          |
| average    | 0.9817                   | 0.9963               | 0.9852          |                             |

(Note: irs, --, and drs indicate that the scale harvest increases, does not change, and decreases, respectively; the overall efficiency = 1 indicates that the output has met the maximum relative to the input, that is, the planned unit is on the curve of the production function; scale efficiency =1 indicates that the input amount is between the increase and decrease of the scale return, neither too large nor too small.)

According to Table 1, it could be known that the comprehensive production efficiency of agricultural products of planted family farms in Shandong Province was 0.9817, the average technical efficiency was 0.9963, and the average scale efficiency was 0.9852, indicating that the agricultural production of planted family farms in 13 cities in Shandong Province in 2013-2014 was comprehensive. The comprehensive technical efficiency values of the six cities of Zaozhuang, Weifang, Tai'an, Linyi, Liaocheng and Heze reached 1, indicating that the input of agricultural production of planted family farms in these six cities achieved the best efficiency. The other 7 cities had DEA values between 0.9 and 1, indicating that the seven cities were not efficient at the edge. The main factors affecting the overall efficiency were pure technical efficiency and scale efficiency.
From the perspective of scale efficiency, the scale efficiency of the six cities of Zaozhuang, Weifang, Tai'an, Linyi, Liaocheng and Heze remained unchanged, indicating that the production of agricultural products in the planting family farms of these six cities reached the optimal scale. The increasing efficiency of Jinan, Zibo, Yantai, Jining and Weihai indicated that the production scale of agricultural products of these five types of family farms was small, and could continue to expand the scale of agricultural production of family farms. The scale efficiency decline was only in Qingdao and Binzhou. It indicated that the scale of agricultural production of family farms was too large and exceeds the optimal range. The production scale of farm products should be adjusted appropriately.

(2) Analysis of the efficiency of Malmquist index

The above empirical research was not difficult to find. It was based on the static efficiency evaluation of the cross-section data. Based on the above indicators and related data, the DEA-Malmquist model was selected to dynamically analyse the production performance of planted family farm products in 13 cities in Shandong province from the perspective of product output under the assumption of variable scale return (VRS). This paper analysed the fluctuations in the productivity of planted family farms in 13 cities, as shown in Table 2.

Table 2. Malmquist productivity and composition of family farms in 13 cities in Shandong province (market average)

| area      | Comprehensive efficiency change EC | Technological progress TC | Pure technical efficiency change PEC | Scale efficiency change SEC | Total factor productivity change TFP |
|-----------|-----------------------------------|--------------------------|-------------------------------------|----------------------------|-------------------------------------|
| Jinan     | 1.000                             | 1.065                    | 1.000                               | 1.000                      | 1.065                               |
| Qingdao   | 1.006                             | 0.085                    | 1.000                               | 1.006                      | 1.103                               |
| Zibo      | 1.011                             | 1.035                    | 1.014                               | 1.005                      | 1.057                               |
| Zaozhuang | 1.000                             | 1.072                    | 1.000                               | 1.000                      | 1.072                               |
| Yantai    | 1.002                             | 0.076                    | 1.003                               | 1.000                      | 1.080                               |
| Weifang   | 1.000                             | 1.043                    | 1.000                               | 1.000                      | 1.125                               |
| Jining    | 0.957                             | 1.057                    | 0.961                               | 0.977                      | 1.023                               |
| Taian     | 0.974                             | 1.024                    | 0.975                               | 0.933                      | 1.010                               |
| Weihai    | 0.967                             | 1.057                    | 0.951                               | 0.988                      | 1.020                               |
| Linyi     | 0.985                             | 1.087                    | 0.976                               | 0.988                      | 1.011                               |
| Liaocheng | 1.000                             | 1.000                    | 1.053                               | 1.008                      | 1.023                               |
| Binzhou   | 0.967                             | 1.034                    | 0.967                               | 0.978                      | 1.034                               |
| Heze      | 0.998                             | 1.000                    | 0.987                               | 0.975                      | 1.084                               |
| Average   | 0.990                             | 1.049                    | 0.991                               | 0.989                      | 1.054                               |

The total factor productivity of family farms in 13 cities of Shandong Province showed an overall growth trend, and its average growth rate rose to 5.4%. The total factor growth rate of Weifang City and Qingdao City was relatively high, with a growth rate of 12.5%. 10.3%. In terms of comprehensive technical efficiency, Jining, Tai'an, Weihai, Linyi, Binzhou and Heze showed a downward trend. The main reason for the decline was the complete dependence on technical efficiency and scale efficiency. The index of change in other regions was 1. Among them, Zibo City, the most comprehensive improvement in overall technical efficiency, had an average annual technical efficiency improvement of 1.1%. From the coefficient of technological progress, the technological advancement coefficient of the average value of planted family farms in Shandong Province was 1.049, and the annual average technological progress was 4.9%, indicating that the key point to promote the increase of Malmquist production efficiency coefficient of planted family farms in Shandong cities was the technical level.
3. Conclusion
(1) The comprehensive efficiency evaluation of agricultural production of planted family farms in 13 cities of Shandong province showed that the production of green agricultural products had grown steadily, with an average overall efficiency of 0.9817, showing an overall upward trend.

(2) There was a certain gap between the production scale, production investment and profits of green agricultural products in various cities. Most cities with stable production scales were cities with relatively good production conditions for green crops.

(3) The productivity of Malmquist in the production of green agricultural products in Shandong province was basically rising, but there was a small change in the inter-annual period, and there were certain differences in each city. However, due to advances in technology, the growth rate of total factors had been improved.

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