

# Evaluation of Operating Efficiency of Agricultural Listed Enterprises Based on DEA-Tobit Two Stage Model

Li-ping YAN\*

Department of Economic Management, North China Electric Power University, Baoding City, Hebei Province, China

\*Corresponding author

**Keywords:** Agricultural listed enterprises, Efficiency, DEA, Tobit.

**Abstract.** This paper used DEA model to evaluate the operating efficiency of sample enterprises, and analyzed the influencing factors of business efficiency through Tobit regression. The results of DEA evaluation show that the operating efficiency of the listed agricultural enterprises is low and the difference between enterprises is obvious. The Northeast comprehensive efficiency, pure technical efficiency and scale efficiency is highest; Forestry, animal husbandry, farming, fishery and agricultural service industry's comprehensive efficiency, pure technical efficiency decrease in turn; In addition to the low scale efficiency of fisheries, the rest of the industry scale efficiency is almost the same. Tobit regression analysis shows that the age, scale of enterprises and the nature of controlling shareholders are negatively related to business efficiency, and total assets return rate and ownership concentration are positively related to business efficiency.

## Introduction

Meng Lingjie et al. (2005) found that the average efficiency of the sample companies is low, and is influenced by factors such as the company's operation time and business direction<sup>[1]</sup>. Wang Qian and Qin Fu (2009) use the DEA model to evaluate the efficiency of the 42 listed agricultural enterprises in China in 2007 and carry out the projection analysis<sup>[2]</sup>. Du Chuanzhong et al. (2009) used Malmquist efficiency index to evaluate the dynamic change of enterprise's efficiency level<sup>[3]</sup>. Yuan Bin et al. (2015) evaluated the input-output efficiency of 109 agricultural industrialization leading enterprises in Nanjing in 2012. It was found that the productivity of the agricultural leading enterprises was "U" distribution with the upgrading of the grade, and the influence factors of the efficiency difference were analyzed by the Quantile regression<sup>[4]</sup>. Wang Liming and Wang Yubin (2015) concluded that the efficiency of food leading enterprises is generally low, but it shows an upward trend and the difference of the comprehensive efficiency of enterprises in different regions is obvious<sup>[5]</sup>.

The above research results have played an useful reference for the correct evaluation of the efficiency level of Chinese listed agricultural enterprises and the efficiency promotion of the listed agricultural enterprises. However, most of these studies lack systematic and in-depth analysis. Based on the comprehensive evaluation of the operational efficiency of agricultural listed companies by using the DEA model, this paper makes a thorough and comprehensive analysis of the comprehensive efficiency, scale efficiency and technical efficiency of enterprises from the perspective of enterprise size, industry category and regional distribution.

## Data Sources and Research Methods

### Data Sources

In this paper, 62 companies with agriculture, forestry, animal husbandry and fishery as the main business activities and engaged in the processing of agricultural and sideline products in the Shanghai and Shenzhen A stock market in 2016 are the research samples. After removing samples from ST enterprises and data that did not meet the requirements of analysis, the final valid samples are 52. Shown in Table 1 and Table 2.

Table 1. The economic regional distribution of the sample

Economic Region	Number	Proportion(%)
Northeast Region	5	9.62
Eastern Region	27	51.92
Central Region	12	23.08
Western Region	8	15.38
Total	52	100

Table 2. Sample industry distribution

Industry	Number	Proportion(%)
Manufacturing Industry	19	36.54
Farming Industry	31	59.62
Health and Social Work	1	1.92
Wholesale and Retail	1	1.92
Total	52	100

## Research Methods

**DEA Model.** Frontier Analysis is one of the common methods to measure the efficiency of enterprise production. Data envelopment analysis (DEA), created by A. Charnes and W.W.Cooper in 1978, is the most widely used<sup>[6]</sup>.The basic models of DEA include C<sup>2</sup>R (constant scale reward) model and BC<sup>2</sup> model (variable scale reward).Based on the input orientation, this paper uses the variable scale reward BC<sup>2</sup> model to calculate the efficiency of the agricultural listed enterprises. The concrete model is as follows:

$$\begin{aligned}
 & \min [ \theta - \varepsilon ( e_1^T S^- + e_2^T S^+ ) ] \\
 & \left\{ \begin{array}{l} \sum_{j=1}^n \lambda_j x_j + S^- = \theta x_0 \\ \sum_{j=1}^n \lambda_j y_j - S^+ = y_0 \\ \sum_{j=1}^n \lambda_j = 1 \\ \lambda_j \geq 0, \\ j = 1, 2, \dots, n \\ S^+ \geq 0, S^- \geq 0 \end{array} \right. \quad s.t. \quad (1)
 \end{aligned}$$

In the formula,  $\theta$  is the pure technical efficiency of the decision unit;  $\varepsilon$  is non Archimedes infinitesimal;  $x_j$  and  $y_j$  are the input and output of j decision unit;  $\lambda_j$  is the weight of j decision unit;  $S^+$  and  $S^-$  respectively represent the relaxation variables that adjust the structure of the decision unit according to the efficiency target.

**Tobit Model.** Tobit regression model is a model with limited dependent variables. Its concept was first proposed by James Tobin (1958)<sup>[7]</sup> and then adopted by economist Goldberger (1964)<sup>[8]</sup> for the first time. The concrete model is as follows:

$$y_i = \beta_0 + \beta_i x_i + \varepsilon_i \quad (2)$$

In the formula,  $y_i$  is the dependent variable, which is the comprehensive efficiency of the listed agricultural enterprises calculated by the DEA model.  $x_i$  is the independent variable that affects the comprehensive efficiency.  $\beta_0$  is a constant term.  $\beta_i$  is the regression coefficient of the independent variable.  $\varepsilon_i$  is a random perturbation term.

## Empirical Analysis

### DEA Evaluation of the Efficiency of Agricultural Listed Enterprises

**Variable Selection.** The operating scope of the listed agricultural enterprises involves many industries, such as planting, animal husbandry, forestry, fishery, agricultural services, food processing. Their raw materials, products, output value and other indexes are different. Therefore, these indicators should not be used as the input and output indicators in the DEA model. The input index should be able to reflect the scale of the enterprise and the utilization of resources, and the output index should be able to reflect the operational results. Therefore, the total assets, operating costs and management costs at the end of the year are selected as the input indicators, and the net profit is selected as the output index. The description and descriptive statistics of the variables are shown in Table 3.

Table 3. Variable description and descriptive statistics in DEA model

Variables		Description	Mean	Standard Deviation	Maximum	Minimum
Output	Net profit	Net profit at the end of the year / million RMB	282.55	427.61	2469.07	2.02
Input	Total assets	Total assets at the end of the year / million RMB	6586.40	7031.79	37385.04	238.42
	Operating costs	Operating costs during the annual accounting period/million RMB	4574.02	9152.95	56027.49	4.92
	management costs	Management costs during the annual accounting period/million RMB	286.11	391.32	1710	15.76

### Analysis of Efficiency Evaluation Results

**Comprehensive Efficiency Evaluation.** Run deap2.1 software to get 52 listed agricultural enterprises' comprehensive efficiency. Among 52 listed agricultural enterprises in 2016, there were 4 enterprises with a comprehensive efficiency of 1, accounting for only 7.69%.The efficiency value of 30 enterprises is less than 0.2, accounting for 57.69% of the total sample. On average, the comprehensive efficiency is 0.28, the pure technical efficiency is 0.43, the scale efficiency is 0.58. Therefore, the production efficiency of the listed agricultural enterprises is low, and the polarization is serious. As shown in Figure 1.

The reason for this phenomenon may be: on the one hand, the weakness of agriculture itself restricts the development space of agricultural listed companies; On the other hand, some agricultural listed companies are engaged in diversified non-agricultural investment. The uncertainty of the technical market in the cross industry affects the benefit of the enterprise and makes the value of the comprehensive efficiency low. It is found that there is a more serious "non-agricultural" phenomenon in the companies with poor efficiency, such as Luoniushan, HOMEY, SHUNXIN AGRICULTURE and KONDARL. Among them, KONDARL's main business involves four sectors: modern agriculture, public utilities, real estate and financial investment, and its comprehensive efficiency is the lowest among 52 sample enterprises, only 0.01.

As  $Crste = Vrste \times Scale$ ,  $Vrste$  and scale will have a direct impact on the comprehensive efficiency. According to the results of the study, there are 36 samples with increasing returns to scale, accounting for 69.23%. There are 9 samples of diminishing returns of scale, accounting for 17.32%. There are 7 samples of constant returns of scale, accounting for 13.45%. This shows that nearly 70% of the listed agricultural enterprises fail to make full or rational use of production factors, which results in the low scale efficiency of enterprises. Compared with the scale efficiency average value of 0.58, the 52 enterprises'  $Vrste$  is more lower, only 0.43, indicating that the technology added value of Chinese agricultural listed companies is low, and technology input and innovation need further strengthening.

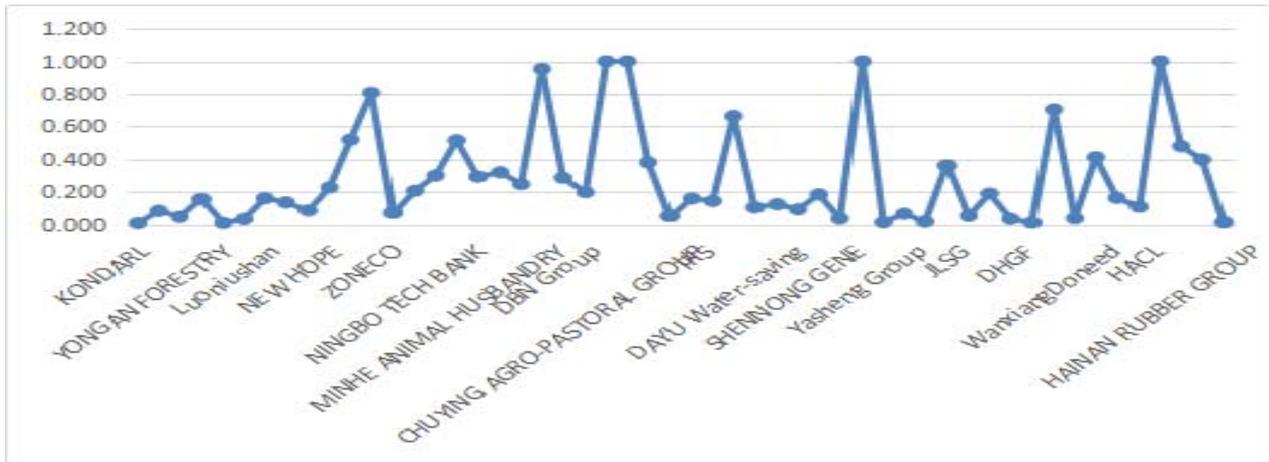


Figure 1. Crste of the Listed Agricultural Enterprises

**Evaluation of Different Region Groups.** In the sub economic region, the Crste in the Northeast, Eastern, Central and Western region is decreasing in turn. The Vrste of the Northeast is the highest, and that of the Eastern region is the lowest. The Scale of the Northeast is the highest, and that of the Central region is the lowest. This shows that the Crste, Vrste and Scale of the Northeast region are the highest. In this study, 2 of the 4 effective DEA samples are located in the Northeast. This is closely related to the regional characteristics of the Northeast region. According to the "Division of Eastern, Western, Central and Northeast Regions" published by the National Bureau of Statistics of the People's Republic of China in 2011, the Northeast region includes Liaoning province, Jilin province and Heilongjiang province. The area has obvious regional characteristics, and its topography is diverse, which provides conditions for agricultural diversified economy. It can be divided into forestry and special production area, farming area and animal husbandry area. As the largest commodity grain base in the China, the Sanjiang plain is a commodity grain base with the highest grain commodity rate in China, with a high level of scale, mechanization and specialization. And, as China northeast old industrial base, industrial base and convenient transportation are conducive to the development of agriculture industrialization, cultivate a number of well-known agricultural leading enterprises, such as HACL, Yiqiao shares.

Table 4. Mean of sample efficiency in different regions

Region	Number	Crste	Vrste	Scale
Northeast Region	5	0.51	0.59	0.72
Eastern Region	27	0.28	0.39	0.64
Central Region	12	0.25	0.45	0.46
Western Region	8	0.22	0.47	0.49
Total	52	--	--	--

**Evaluation of Sub Industry Group.** The results of the group evaluation are shown in Table 5.

The Crste and Vrste of forestry, animal husbandry, planting, fishery and agricultural services are reduced in turn. In addition to the low efficiency of fishery, the Scale of the rest of the industry is almost equal.

Since 12th Five-Year Plan the scale of China's forestry industry has been expanding, and its output value has increased continuously, from 2 trillion and 280 billion RMB in 2010 to 7 trillion RMB in 2017. Forest products trade has been ranked the first in the world. At the same time, there is still a low proportion of high value-added products in China's forestry, and the huge production potential of forestry has not been fully developed<sup>[10]</sup>. The main business of Pingtan, FUJIAN JINSEN and YJFC is forest cultivation, forest maintain, timber production and sales. It is in line with the concept of green development in China. These enterprises are in the stage of increasing returns to scale, and still have greater space for development and promotion.

Table 5. Sample efficiency in sub industry

Sub-industry	Number	Crste	Vrste	Scale
Forestry	3	0.47	0.64	0.63
Animal Husbandry	8	0.46	0.60	0.76
Crop Farming	9	0.33	0.42	0.61
Fishery	9	0.21	0.35	0.43
Agricultural Service Industry	2	0.06	0.12	0.61
Total	31	--	--	--

Since the reform and opening up, China's livestock industry has been developing steadily. With the implementation of the policy of strengthening agriculture and benefiting farmers, animal husbandry production mode has changed positively, and the scale, standardization, industrialization and regionalization have been quickened. This is in accordance with the results of the study.

The Crste and Vrste of the planting samples are low. This shows that the production of China's planting industry should continue to improve the structure and the quality, and develop high quality and special agricultural products.

The Crste, Vrste and Scale of the fishery are greatly lower than that of the forestry, animal husbandry and planting. Of the 9 fisheries enterprises, 8 enterprises are in the stage of increasing returns to scale. Therefore, the transformation and upgrading of Fisheries should be accelerated in the future, and it will be developed in the direction of scale and intelligence.

The results show that the efficiency of agricultural service enterprises in China is low, and the level of industrialization and scale needs to be further improved. In the future, we must vigorously develop diversified, multiple level and type agricultural productive services, promote the development of various forms of moderate scale operation, drive more farmers to enter the track of modern agricultural development, and comprehensively promote the construction of modern agriculture<sup>[11]</sup>.

### **Tobit Regression of the Influence Factors of Crste**

**Variable Selection.** This paper chooses the corresponding explanatory variables from the aspects of enterprise age, enterprise scale, assets operation capacity, ownership structure and the nature of the actual controller.

Enterprises with long listed years are more experienced in business experience and stronger in market competitiveness, thus the operating efficiency may be higher than that of short listed companies. The age of the sample enterprise is the years for listing by 2016. The larger the scale of the enterprise, the more likely it will bring the scale effect and improve the efficiency of the scale. ROA refers to the ratio of the total amount of remuneration to the average of the assets obtained in a certain period of time. It represents the overall profitability of all assets, including net assets and liabilities. The higher the index, the better the level of the input-output, the more effective the operation of the enterprise's assets. It is generally believed that the higher the ownership concentration of the enterprise, the shareholders will take various measures to improve the value of the enterprise, so that the interests of the enterprises will converge with the interests of the enterprises. In this paper, the ownership concentration is expressed as the first largest shareholder's shareholding ratio. The actual controller is a dummy variable. When state ownership is holding, the value of the variable is 1, otherwise it is 0. The description of the variables is shown in Table 6.

Table 6. Variable description of Tobit model

Variables	Implication	Type	Mean	Maximum	Minimum
Independent Variable					
Crste	Crste obtained by the DEA model	Censored Data[0,1]	0.283	1.000	0.010
Dependent Variable					
Enterprise Age	Years for listing by 2016	Continuous	13	23	5

Enterprise Size	Natural logarithm of total assets at the end of the year	Continuous	8.28	10.53	5.47
ROA	$ROA = (\text{Profit} + \text{Interest expenditure}) / \text{Average total assets} \times 100\%$	Continuous	4.57	30.45	0.27
Ownership Concentration	The first largest shareholder's shareholding ratio(%)	Continuous	34.17	70.32	9.49
Nature of Controlling Shareholders	State-holding=1 Non state holding=0	Dummy	--	--	--

Note: the data of the dependent variables are from the annual reports disclosed by the enterprises in 2016.

**Analysis of Regression Results.** Stata13.1 software was used for Tobit regression. The results are shown in Table 7.

The coefficient of the age of the enterprise is negative and the value is small, but it is not significant, indicating that the years of listing is negatively related to Crste but has little influence. Although the earlier listed companies have accumulated some experience in the market, it may be difficult to adapt to the changing market competition environment due to the old system and backward technological innovation, thus affecting the improvement of enterprise management level. On the contrary, newly listed companies are more responsive to the demand and environment of the current market because of the pace of technological progress, so the efficiency will be higher.

The size of the enterprise is negatively related to Crste and has a significant influence. The essence of scale benefit is that the proportion of the increase of enterprise output is greater than that of all inputs. Therefore, blindly expanding the scale of assets will not improve business efficiency. Only by constantly improving the level of asset management can we improve business efficiency.

ROA is positively related to Crste and has significant influence. That is, firms with higher ROA have higher input and output level and the more effective assets operation is. Therefore, the enterprises should pay attention to the factor.

The ownership concentration is positively related to Crste, but it is not significant. The higher concentration of ownership can enable enterprises to respond quickly to the complex market competition environment and achieve higher operational efficiency. But "the only big shareholder" can easily lead to the self-interest of the large shareholders in theory, which is not conducive to the promotion of business efficiency.

The nature of the controlling shareholders is negatively related to Crste but not significant. According to the theory of "grabbing hands", state holding will produce a series of problems such as the absence of actual controllers and so on. It is difficult to achieve effective supervision of enterprise operation and management, and ultimately lead to the exacerbation of insider control problems, which is not conducive to the improvement of business efficiency.

Table 7. Regression results of Tobit model

Dependent Variable	Coefficient	Standard Error	P
Enterprise Age	-.0071381	.0063412	0.266
Enterprise Size	-.0632654	.0292569	0.036
ROA	.0473117	.0094597	0.000
Ownership Concentration	.0038266	.0022351	0.093
Nature of Controlling Shareholders	-.0232518	.0716777	0.747
cons	.5793846	.258434	0.030
LR chi2	40.78		
Prob > chi2	0.0000		

Note: the significant level is 5%.

## Conclusions

Taking 52 listed agricultural enterprises in China as samples, the DEA model is used to measure their business efficiency in 2016. Meanwhile, the influencing factors of their business efficiency are analyzed by using Tobit model. The conclusions are as follows:

a) The operating efficiency of the listed agricultural enterprises is low and the difference between enterprises is great. The Crste value of 4 enterprises is 1, accounting for 7.69%, and that of 30 enterprises is less than 0.2, accounting for 57.69%. The Crste, Vrste and Scale of the Northeast region are the highest. The Crste and Vrste of forestry, animal husbandry, planting, fishery and agricultural services are reduced in turn. In addition to the low efficiency of fishery, the Scale of the rest of the industry is almost equal.

b) The size of the enterprise is negatively related to Crste and has a significant influence. ROA is positively related to Crste and has significant influence.

c) The ownership concentration is positively related to Crste, but it is not significant. The nature of the controlling shareholders is negatively related to Crste but not significant. The stock ownership structure of Chinese listed companies is unreasonable, especially the absence of large shareholders in state-owned enterprises, which leads to the lack of internal supervision mechanism.

### **Acknowledgement**

This research was supported by 'the Fundamental Research Funds for the Central Universities (2018 MS148)'.

### **References**

- [1] MENG Lingjie, DING Zhu, DEA based efficiency analyses of the listed agricultural companies, *J. Journal of Nanjing Agricultural University (Social Sciences Edition)*.2(2005)39-43.
- [2] Wang Qian, Qin Fu, Analysis on production efficiency of leading agricultural enterprises in China: based on DEA model, *J. Technology Economics*.Vol28, 3(2009)53-57.
- [3] DU Chuanzhong, LV Kun, LIU Yuhai, An empirical study on the production efficiency of the listed companies in China's brewery industry -- two stages analysis based on the DEA model, *J. Inquiry Into Economic Issues*. 11(2009) 87-93.
- [4] YUAN Bin, CHEN Chao, TAN Tao, Research on the difference of production efficiency of agricultural leading enterprises of different grades -- an empirical analysis based on the agricultural leading enterprises in Nanjing, *J. Issues in Agricultural Economy*. 11(2015)80-87.
- [5] WANG Liming, WANG Yubin, Analysis of the efficiency of China's leading agricultural enterprises and its influencing factors--based on the national grain leading enterprises, *J. Modernization of Management*.6(2015)100-102.
- [6] Charnes A, Cooper W.W, Rhodes E, Measuring the efficiency of decision making units, *J. European Journal of Operational Research*.Vol.2,6(1978)429-444.
- [7] James Tobin, Estimation of relationships for limited dependent variables, *J. Econometrica*, Vol. 26, 1 (Jan., 1958) 24-36.
- [8] Goldberger, A. S, *Econometric Theory*, New York: Wiley, 1964.
- [9] SHENG Zhaohan, ZHU Qiao, WU Guangmou, *DEA theory, method and application*, Beijing: Science and Technology Press, 1996: 153-158.
- [10] The State Forestry Administration of the People's Republic of China. Plan for the development of forestry in 13th Five-Year, 2016-05-06.
- [11] On [http://jiuban.moa.gov.cn/zwillm/tzgg/tz/201708/t20170823\\_5791602.htm](http://jiuban.moa.gov.cn/zwillm/tzgg/tz/201708/t20170823_5791602.htm).