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Research Article

Research on Financial Performance Evaluation of Listed Agricultural Companies in China——Based on VRS-DEA and Malmquist Index

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Abstract: On the basis of sorting the development of the theory of company performance evaluation, this study uses the VRS-DEA model and Malmquist index to evaluate the financial performance of 12 listed agricultural companies in China. Firstly, the selected sample data was standardized, and then the VRS-DEA model was used to analyze the financial performance indicators of the sample companies in 2019. Secondly, the financial performance indicators of the sample companies from 2015 to 2019 were used to longitudinally analyze the company's total factor productivity through the Malmquist index. Finally, based on the analysis of the financial performance evaluation results of sample companies, some suggestions for improving the financial performance of listed agricultural companies in China are put forward.

Keywords: Efficiency evaluation; Financial performance; DEA; Total factor productivity

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1 Introduction

Agriculture is the basic industry of the Chinese national economy. Whether agriculture can achieve long-term and good development is related to the Chinese national economy and people's lives. Listed agricultural companies are an important representative of China's agricultural management industrialization. They have relatively advanced governance structures, transparent financial systems, and high-quality assets and equipment. The actual financial status of listed companies will not only have a significant impact on China's securities market, but is also closely related to the development of Chinese national economy. The history of corporate performance evaluation can be traced back to the mid-19th century. The main focus of performance evaluation at that time was the internal production efficiency of the enterprise. The content of the assessment was mainly the assets and liabilities in the balance sheet and the profits in the income statement. In 1920, the American company DuPont used the financial performance evaluation method for the first time to evaluate the performance of the enterprise by the return on investment equal to the net asset interest rate multiplied by the equity multiplier, and finally formed the DuPont analysis system for enterprise performance evaluation, which is still widely used. In 1978, Charnes, Copper, Rhodes and other scholars evaluated from the perspective of production, measured the relative effectiveness of multi-input and multi-output evaluation units, and established the theory and methods of data envelopment analysis (DEA). In later research, A. Chames and W. Cooper further extended Farrell's theory to multi-input multi-output non-parametric analysis to create a DEA model, and gradually improved the basic research of DEA. Scholars such as Fare (1994) defined an output-based productivity index to measure changes in total factor production efficiency called Malmquist TFP index. Later, the index formula was broken up to break down the changes in technical efficiency into pure technical efficiency and scale efficiency, which

makes the Malmquist index more widely used in the research of evaluating target production efficiency[1]. Chinese scholars have been using various methods to continuously explore the financial performance evaluation of listed companies. Han Suochang (2007) selected 37 listed agricultural companies when analyzing the financial performance of listed companies in China, and applied the DEA method to the financial performance evaluation of agricultural companies in China. Based on the innovation system theory and using the DEA method, Shi Yanwen, Li Erling (2012) conducted a performance evaluation analysis on the innovation and development of 27 enterprises in the flower and tree industry cluster in Yanling County[2]. It is believed that the improvement of scale efficiency requires enterprises to increase investment in scientific research and personnel training, further the integration of production, education and research, and strengthen the management system. He Jiaqi (2013) constructed a three-module comprehensive evaluation model from different aspects when evaluating the financial performance of listed forestry companies, and made a reasonable, scientific and comprehensive evaluation on the financial performance of listed forestry companies[3]. Wang Tie, Yang Linjuan et al. (2014) evaluated the performance of key national leading enterprises in Gansu agricultural industrialization based on the DEA method, and showed that DEA ineffective leading enterprises generally have human and asset redundancy[4]. Based on previous researches on the financial performance of listed companies by related scholars, this study took 12 listed agricultural companies in China from 2015 to 2019 as the research subjects. The output and input-output indicators of the samples were first standardized, and then the VRS-DEA model and Malmquist index were used to evaluate the financial performance of these 12 listed agricultural companies.

2 Research Design

2.1 Selection of Evaluation Index

Through the analysis and research on the literatures of financial performance evaluation theory and DEA method etc., with reference to the scholars' choices of indicators for companies' financial performance evaluation, this study agrees that the building of the listed agricultural companies' financial performance evaluation system should follow the principles of systemicity, priority and operability[5]. Output indicators are usually selected to represent profitability and debt solvency, and input indicators are usually selected to represent costs and asset scale. Meanwhile, according to the principle of maximizing enterprise profits, when the output is unchanged, the expectation is that the input can be smaller; when the input is unchanged, the expectation is that the output can be greater. Therefore, in the selection of output indicators, three indicators that can reflect the profitability of agricultural companies were selected, namely: main business income, net profit, and earnings per share; when selecting input indicators, total assets and operating costs were chosen in this study to reflect the agricultural companies' operating investments. These five indicators can generally reflect the basic input-output performance of listed agricultural companies. The standardized value of the sample indicators of China's agricultural listed companies from 2015 to 2019.

2.2 Sample Selection and Data Source

This study selected the data of agricultural companies listed on the Shanghai and Shenzhen stock exchanges from 2015 to 2019 as the research samples (the agriculture does not include forestry, animal husbandry, and auxiliary fishing). The main source of data is the data from the financial statements and fundamental analysis reports in the CSMAR database, and the data was processed as follow: (1) According to the 2012 industry classification standards, the data of companies with abnormal listing status and poor operations (ST, *ST) were excluded, and companies that were not listed before 1st January 2015 were also excluded (Zhongxing Fungus Industry and Xuerong Biology). Finally, 12 companies were selected as samples; (2) Since net profit and earnings per share have negative values (the DEA model input cannot have negative values), the sample data is standardized using the extreme value method, so that all sample data values are between 0 ~1, the results are shown in the appendix. Data processing and analysis were mainly performed using EXCEL and Deap 2.1 software.

2.3 Model Settings

Basic formulas of VRS-DEA model:

$$s.t.\begin{cases} min[\theta - \varepsilon(e^t s^- + e^T s^+)] = V_D \\ \sum_{j=1}^{n} X_j \lambda_j + S^- = \theta X_0 \\ \sum_{j=1}^{n} Y_j \lambda_j - S^+ = Y_0 \\ \lambda \geq 0;\ j = 1,2,\ldots,n; s^+ \geq 0, s^- \leq 0 \end{cases}$$

Where e^t=(1,1,...,1) ∈ E_m; e^T=(1,1,...,1) ∈ E_s. ε is non-Archimedes infinitesimal, during calculations, usually it was assumed that $\varepsilon=10^{-4}$. s^-, s^+ are slack variables.

Based on DEA model, Malmquist Index was broken down, the formula as follow:

tfp*ch*=effch*techch=*pech*techch*sec *h*

Tfpch is the total factor productivity, when tfpch>1, it indicates increase in total factor productivity. When any one of the factors among pure technological efficiency (pech), technology change index (techch) and scale efficiency (sech) is greater than 1, the increase in total factor productivity is promoted[6].

3 Empirical Analysis

3.1 VRS-DEA Horizontal Evaluation Process

3.1.1 Analysis of the overall efficiency, pure technological efficiency and scale efficiency of the sample companies in 2019

The sample data was imported into the Deap 2.1 software, and through the calculation of the VRS-DEA evaluation model, the financial performance measurement results of the 12 listed agricultural companies in China in 2019 were obtained, as shown in Table 1.

Table 1. Financial Performance of 12 Listed Agricultural Companies in China in 2019

Stock Name	Stock Code	Overall Efficiency	Pure Technological Efficiency	Scale Efficiency	Return to Scale
Yuan Long Ping High-Tech	000998	0.434	0.453	0.957	Drs
Denghai Seed Industry	002041	0.462	0.462	1	—
Winall Hi-tech Seed	300087	1	1	1	—
Hainan Shennong Technology	300189	0.207	0.207	0.997	Irs
YaSheng Group	600108	0.496	0.554	0.894	Drs
Zhongnongfa Seed Industry	600313	1	1	1	—
Xinjiang Talimu Agriculture Development	600359	0.51	0.51	1	—
Wanxiang Denon	600371	0.747	1	0.747	Drs
Xiangli Shares	600506	1	1	1	—
Xinjiang Sayram Modern	600540	0.862	0.862	1	—
Beidahuang	600598	1	1	1	—
Hainan Rubber Industry Group	601118	0.739	1	0.739	Drs
Average		0.705	0.754	0.944	

Based on the financial performance values of 12 domestic listed agricultural companies in 2019 listed in Table 1, this study carried out the following analysis from three perspectives: overall efficiency, pure technological efficiency, and scale efficiency:

The overall efficiency represents the DEA effective level of the decision-making unit. When its value is 1, it is considered DEA effective. If it is not equal to 1, it is DEA ineffective. It is a decision-making unit that comprehensively measures the ability of resource allocation and resource utilization efficiency and other aspects of the production front. In Table 1, the overall efficiency of the four companies: Beidahuang, Winall Hi-Tech Seed, Xiangli Shares and Zhongnongfa Seed Industry is 1 and therefore DEA effective, and the pure technological efficiency and scale efficiency are both 1, indicating that in 2019 these 4 listed agricultural companies had high utilization efficiency and more reasonable allocation of financial resources, and their financial performance were at a relatively high level; while the 8 other listed agricultural companies with overall efficiency values of less than 1 were in a DEA inefficient state, indicating that these companies still need to improve as their financial efficiency is not high.

Pure technological efficiency is affected by factors such as enterprise management capability and technological level. In table 1, the pure technological efficiency of Winall Hi-Tech, Beidahuang, Hainan Rubber Industry Group, Xiangli Shares,

Zhongnongfa Seed Industry and Wanxiang Denon is 1, which means effective for pure technological efficiency, and the rest were in a state of ineffective pure technological efficiency. It shows that in 2019, these 6 companies valued the development, innovation and use of advanced technology; while other companies with ineffective pure technological efficiency should learn from companies at the forefront of production, pay attention to technological innovation, increase development expenditures, and introduce scientific research talents to improve the company technological efficiency. In addition, the pure technological efficiency of Wanxiang Denon and Hainan Rubber Industry Group is 1, while the scale efficiency is less than 1, which shows that the technological efficiency of these two companies has reached a good state, and there is no need to change the input and output; and their overall efficiency being less than 1 indicates ineffectiveness due to their scale not matching the input and output, so Wanxiang Denon and Hainan Rubber Industry should reduce their scale.

Scale efficiency represents the impact of changes in enterprise scale on production efficiency. It can be seen from Table 1 that Beidahuang, Winall Hi-Tech, Xinjiang Talimu Agriculture Development, Denghai Seed Industry, Xiangli Shares, Xinjiang Sayram Modern and Zhongnongfa Seed Industry have reached the optimal scale and the optimal allocation of financial resources. The remaining five companies have problems with unreasonable business scale or unsuitable factor allocation structure, showing incremental margin in scale efficiency. Among them, the operation of Shennong Technology needs to increase financial investment and scale expansion; Yuan Longping Hi-Tech, YaSheng Group, Wanxiang Denon and Hainan Rubber need to scale down and reduce financial investment. Meanwhile, non-DEA effective companies can learn management and application from the best companies and find the best way to improve efficiency.

3.1.2 Analysis of Output and Input Slackness of Sample Companies

Based on the output and input slackness of the 12 listed agricultural companies in China as listed in Table 2, the specific analysis on Yuan Longping Hi-Tech and Denghai Seed Industry is given, and the rest of the companies are the same.

Table 2. The Output and Input Slackness of the 12 Listed Agricultural Companies in China

Stock Name	Main Business Income	Net Profit	Earnings Per Dhare	Total Assets	Operation Cost
Yuan Long Ping High-Tech	0	0.443	0.253	-0.503	-0.074
Denghai Seed Industry	0	0.133	0.066	-0.11	-0.02
Winall Hi-tech Seed	0	0	0	0	0
Hainan Shennong Technology	0	0.092	0.132	-0.04	-0.008
YaSheng Group	0	0.289	0.122	-0.229	-0.071
Zhongnongfa Seed Industry	0	0	0	0	0
Xinjiang Talimu Agriculture Development	0	0.06	0.018	-0.043	-0.016
Wanxiang Denon	0	0	0	0	0
Xiangli Shares	0	0	0	0	0
Xinjiang Sayram Modern	0	0.009	0.02	-0.011	-0.012
Beidahuang	0	0	0	0	0
Hainan Rubber Industry Group	0	0	0	0	0

Yuan Longping Hi-Tech's input and output analysis: the slackness variable of the first output indicator, main business income, is 0, there is no redundancy; the slackness value of the second and third output indicators, net profit and earnings per share, are negative, indicating insufficient output, and net profit and earnings per share should increase by 0.443 and 0.253 respectively. The value of the slackness variable of total assets, the first input indicator, is -0.503; the value of the slackness variable of operating cost, the second input indicator, is -0.074. Therefore, Yuan Longping Hi-Tech had output redundancy in 2019, the first input factor can be reduced by 0.503, and the second input factor can be reduced by 0.074.

Analysis of the input and output of Denghai Seed Industry: The first output indicator shows no redundancy in the main business income, and the second and third output indicators show insufficient output, and the net profit and earnings per share

should increase by 0.133 and 0.066 respectively. The first input factor, total asset, has an input redundancy of 0.110; the second input factor, operating cost, has an input redundancy of 0.020. Therefore, the output redundancy of Denghai Seed Industry in 2019 can be reduced by reducing the first input factor by 0.110 and reducing the second input factor by 0.020.

3.1.3 The Weightage Analysis of the Sample Companies Learning from the Best Companies

Table 3 lists the direction and improvement of non-DEA effective companies. Yuan Longping Hi-Tech can learn from the best performing Beidahuang, Zhongnongfa Seed Industry and Winall Hi-Tech, with learning weightage of 0.877, 0.065 and 0.058 respectively; while Denghai Seed Industry can learn from Xiangli Shares, Winall Hi-Tech and Beidahuang as required, the learning weightages are 0.554, 0.294 and 0.152 respectively. Shennong Technology can learn from Winall Hi-Tech, Xiangli Shares and Beidahuang, with learning weightage of 0.946, 0.015 and 0.040 respectively; YaSheng Group, Xinjiang Talimu Agriculture Development and Xinjiang Sayram Modern can learn from Winall Hi-Tech, Zhongnongfa Seeds, Xiangli Shares, Beidahuang and Zhongnongfa Seed Industry, and the learning weightages are shown in the table. Among them, Winall Hi-Tech, Zhongnongfa Seed Industry, Xiangli Shares and Beidahuang had better operations and higher financial performance. They have been learned 6 times, 3 times, 4 times and 5 times by other companies respectively.

Table 3. The Weightage of Learning from the Best Companies for the 12 Listed Agricultural Companies in China

Serial No.	Stock Name	Companies Learned and Weightage			Times Learned by Others
1	Yuan Long Ping High-Tech	3 0.058	6 0.065	11 0.877	—
2	Denghai Seed Industry	3 0.294	9 0.554	11 0.152	—
3	Winall Hi-tech Seed	3 1.000			6
4	Hainan Shennong Technology	9 0.946	11 0.015	3 0.040	—
5	YaSheng Group	6 0.150	11 0.501	3 0.349	—
6	Zhongnongfa Seed Industry	6 1.000			3
7	Xinjiang Talimu Agriculture Development	3 0.413	9 0.567	11 0.020	—
8	Wanxiang Denon	8 1.000			—
9	Xiangli Shares	9 1.000			4
10	Xinjiang Sayram Modern	3 0.488	9 0.354	6 0.158	—
11	Beidahuang	11 1.000			5
12	Hainan Rubber Industry Group	12 1.000			—

The Longitudinal Evaluation Analysis of the Financial Performance of the Sample Companies Based on the Malmquist Index

Deap2.1 software was used to break down the financial data of the research samples from 2015 to 2019 to obtain the index breakdown results of the research samples and each company, as shown in Table 4 and Table 5.

Table 4. The Financial Performance TPF Index of the 12 Listed Chinese Agricultural Companies in 2015-2019

Year	effch	techch	pech	sech	tfpch
2016	0.881	0.014	1.037	0.849	0.012
2017	0.852	22.080	0.846	1.007	18.806
2018	1.138	0.848	1.026	1.109	0.965
2019	0.947	0.032	0.911	1.040	0.030
Average	0.948	0.302	0.951	0.997	0.287

Table 5. Financial Performance TPF Index and Breakdown of the 12 Listed Chinese Agricultural Companies' Branches in 2015-2019

Stock Name	Stock Code	effch	techch	pech	sech	tfpch
Yuan Long Ping High-Tech	000998	0.860	1.083	0.847	1.015	0.931
Denghai Seed Industry	002041	0.825	1.089	0.825	1	0.898
Winall Hi-tech Seed	300087	1	1.040	1	1	1.040
Hainan Shennong Technology	300189	0.778	1.095	0.774	1.005	0.851
YaSheng Group	600108	0.961	1.065	0.989	0.973	1.024
Zhongnongfa Seed Industry	600313	1	1.033	1	1	1.033
Xinjiang Talimu Agriculture Development	600359	0.974	1.020	0.970	1.004	0.994
Wanxiang Denon	600371	0.930	1.068	1	0.930	0.993
Xiangli Shares	600506	1	0	1	1	0
Xinjiang Sayram Modern	600540	1.085	0.994	1.062	1.022	1.079
Beidahuang	600598	1	1.160	1	1	1.160
Hainan Rubber Industry Group	601118	1.013	1.034	1	1.013	1.048
Average	0.948	0.302	0.951	0.997	0.287	

It can be seen from Table 4 and Table 5 that during the five years period from 2015 to 2019, only the techch in 2017 was greater than 1; from 2015 to 2019, except for 2018, the effch was less than 1, indicating that the overall speed of technological progress of each listed agricultural company during the five years was slow, the improvement of technical efficiency was slow, and the innovation capability of agricultural production technology was poor; pure technical efficiency (pech) was greater than 1 in 2016 and 2018, and less than 1 in 2017 and 2019, with an average of 0.951, indicating that the basic coordination of the relationship between the production management and technological innovation capabilities of these agricultural enterprises during was slightly inadequate during 2015-2019; the scale efficiency (sech) was 0.849 in 2016, and was greater than 1 for the other years, indicating that the financial performance of each company in the five years was close to the optimal level scale. From Table 5, it can be seen that from the analysis on the TFP index of the branch companies, in the five years period from 2015 to 2019, the TFP index of 6 listed agricultural companies had a growth rate greater than 1, of which the TFP index of Beidahuang reached 1.160, the highest among the samples. As changes in technical efficiency determine the improvement of the Malmquist index, other companies need to increase technology development expenditures to improve corporate financial performance.

4 Related Suggestions

In 2019, 4 listed agricultural companies (Beidahuang, Quanyin Hi-Tech, Nongfa Seed and Xiangli Co., Ltd.) have relatively high financial performance. Other companies can refer to the input-output ratio and technological R&D investment of these 4 companies, and then improve the redundant input factors or insufficient output.

From the TFP index and breakdown analysis of listed agricultural companies' financial performance, it can be seen that during the five years period from 2015 to 2019, there were 6 listed agricultural companies with a TFP index greater than 1, of which Beidahuang had the highest TFP index, as high as 1.160. Since the key factor in the improvement of total factor productivity is the change in technical efficiency, the financial performance of companies with low TFP index is limited by technical efficiency. Therefore, other listed agricultural companies with slow technological progress can learn from the best companies according to their weightages, strengthen their emphasis on technological innovation, combine production, education and research with actual production, strengthen mutual cooperation and technology sharing, and make

targeted use of international spillover technology. While improving the financial performance of listed agricultural companies, respond to the country's rural revitalization strategy and seize opportunities to develop agriculture better.

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