Business Performance Evaluation of Listed Feed Companies under Epidemic Impact- Based on the DEA-Tobit Model

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Abstract

As a big agricultural country, the development of agriculture is the foundation of China. Meanwhile as a crucial part of Chinese agricultural economy, the steady development of the feed industry is particularly important against the backdrop of the normal development of COVID-19. This paper takes 16 listed feed companies as the research object, and constructs the DEA-Tobit model and evaluates the business performance of them. The results show that, affected by the epidemic, the operating performance of listed feed companies in China presented a downward trend; among the factors affecting business performance, the ratio of technical personnel to total employees had a positive correlation with business performance; the ratio of R&D investment to operating revenue in the first three years was negatively correlated with operating performance, but in 2021, it became positively associated with operating performance. Before the outbreak of the epidemic, the ratio of operating cost to operating revenue had a positive correlation with operating performance, while after the outbreak, the ratio of operating cost to operating revenue had a negative correlation with the company's operating performance.

Keywords: *Listed feed enterprises. DEA-Tobit model. Business performance evaluation. Epidemic*

1. INTRODUCTION

The "14th Five-Year Plan" highlights the need to continuously strengthen the position of agriculture as the foundation, deepening agricultural supply-side structural reform, strengthening quality orientation, and promoting the revitalization of rural industries. As the foundation of Chinese agricultural development, the feed industry is not only an important link between animal husbandry and planting, but also plays an important role in the sustainable development of planting and aquaculture, the improvement of the added value of agricultural products, and the high-quality development of agriculture [10]. In recent years, due to the outbreak of the new champions league, the influence of raw material prices increase feed company needs [2], combined with the epidemic's impact on transportation, greatly increasing the feed companies operating difficulties caused by the increase of operating cost and other issues, therefore, how to balance the relationship between the input and output, improve the business performance is the challenges faced by the current feed enterprises[12]. At present, the domestic

scholars have to feed the business performance of listed companies are as follows, Xu Songjie using DEA method and index Malmquist 14 feed the operating performance of listed companies in China were analyzed, and the total factor is declining, it is concluded that China's feed industry production of feed enterprises operating performance did not reach the optimal state [11]. Dai Chunqian used the factor analysis method to comprehensively evaluate the financial performance management level and effect of listed feed companies, through to the company's debt paying ability, operation ability, profitability and development capacity index analysis, obtained the development potential of feed enterprises, often difficult to get a good market expectations, as feeding enterprise managers should focus on product research and development, technological input and business model innovation to improve the development potential of listed feed enterprises and the confidence of shareholders and investors on listed feed enterprises [4]. Su Xueke used entropy weight TOPSIS method to evaluate the financial performance of feed companies from 2017 to 2019,

constructed the financial performance evaluation system of listed Chinese feed companies, and conclude that solvency has a high impact on the financial performance evaluation of the feed industry [9]. Zhang Xiaoqing used VAR model to study the impact of tax incentives on the performance of listed feed companies in China, and the results showed that R&D intensity and investment scale significantly affected the incentive effect of tax incentives on the performance of listed feed companies (Zhang 2021). Lei Yanli used the SOA algorithm combined with the Z-SCORE model to give early warning of the financial risks of the listed feed companies in China and conclude that the financial situation of the feed industry is good and the financial risk are low [7]. Hu Xiaoping used rough set theory and Rosetta software to build a value evaluation model for listed feed companies, the accuracy of the model reached 80% after testing, which provided reference for listed feed companies to evaluate their own value [5]. Hao Yanhua studied the financial performance of Chinese listed feed companies based on AHP-DEA model and pointed out that the comprehensive efficiency of the financial performance of Chinese listed feed companies was at a general level, and financial management、technology and scale factors all had an impact on the financial performance [6].

To sum up, the current research on the operating performance of my country's listed feed companies is mainly divided into two categories: one is the research on the construction of the financial performance evaluation system of listed feed companies; the other one is to study the factors affecting the performance of listed feed companies. The current research on the operating performance of listed feed companies mainly discusses the construction of financial performance system, but the epidemic factors are not considered in the process of constructing the indicator system. With the outbreak of the epidemic, Chinese feed industry is blocked in the import of raw materials, and the price of raw materials increases greatly, which has a great impact on the business performance of listed feed companies [3]. Therefore, this paper constructed the DEA-Tobit model to evaluate the business performance of listed feed companies in China under the background of epidemic situation, and explored the factors affecting the business performance of listed feed companies before and after the outbreak of epidemic situation, so as to help feed enterprises take more targeted measures to improve business management, optimize resource allocation and achieve effective operation.

2. METHODOLOGY

Data Envelopment Analysis (DEA) is a quantitative analysis method to evaluate the relative effectiveness of comparable DMU by using linear programming method according to a number of input and output indexes. DEA method can be used to understand the size of the performance of each decision-making unit from the static level, but it is difficult to find the factors influencing the business performance of feed companies on the whole [1].

According to the types of production scale return, DEA model can be divided into fixed scale return model (CCR) and variable scale return model (BCC). However, in the actual production process of enterprises, every DMU is not fixed scale return, according to the actual operation situation of listed feed companies, this paper adopts output-oriented BCC model as follows:

$$\begin{cases} \min[\beta - \varepsilon(\hat{e}^T \delta^- + e^T \delta^+)] \\ s.t. \sum_{j=1}^{n} \partial_j + x_j + \delta^- = \beta x_0 \\ \sum_{j=1}^{n} \alpha_j y_j - \delta^+ = y_0 \\ \sum_{j=1}^{n} \alpha_j = 1, \alpha_j \geq 0, j = 1, 2, ..., n \\ \hat{e}^T = (1,1,...,1) \in E_m, e^T = (1,1,...,1) \in E_s \end{cases}$$

where β is the efficiency value of the DMU decision unit, and α_j represents the combination ratio of the JTH decision unit in an effective DMU combination The validity of the model is judged as follows: if $\beta = 1$, $\delta^- = \delta^+ = 0$, the DMU is DEA effective, that is, both scale efficiency and technical efficiency is efficiency; if $\beta = 1$, $\delta^- \neq 0$ 或 $\delta^+ \neq 0$, then the DMU is weak DEA effective, that is, the scale efficiency and technical efficiency are not effective at the same time; if $\theta < 1$, the DMU is DEA invalid, that is, neither scale efficiency nor technical efficiency is valid [8].

Tobit model refers to a type of model in which the dependent variable is roughly continuously distributed within the value range greater than 0, but contains the observed value of 0. The standard Tobit regression model is as follows:

$$\begin{cases} Y_i^* = x_i \beta + \varepsilon_i \\ Y_i = Y_i^* (Y_i^* > 0) \\ Y_i = 0 (Y_i^* \leq 0) \end{cases}$$

Among them, Y_i^* is the latent variable, Y_i is the observed dependent variable, X_i is the independent variable vector, β is the correlation coefficient vector, ε_i s the interference term, independent and obeys the normal distribution with mean 0 and variance σ, that is $\varepsilon_i \sim N(0, \sigma)$, therefore $Y_i^* \sim N(X_k \beta, \sigma)$.

3. DEA model specification

3.1. Indicator selection

By summarizing the literature and combination with the current feed of listed companies in China, this paper constructs the feed listed companies operating performance evaluation index system as shown in table 1,enterprise investment mainly includes three aspects of human, material and financial resources, therefore, the year-end number of employees, main business cost and the total assets are selected as input indicators; output of an enterprise is mainly represented by income and profit, so net profit and main business income are selected as output indicators.

Table 1: Operational performance evaluation index system of listed feed companies

category	index	code	meaning
input indicator	Total assets	X_1	The size of the company's assets
	Number of employees at the end of the year	X_2	The company's human capital investment
	Main business cost	X_3	The company's material resources investment
output indicator	net profit	Y_1	The company's operating results
	Main business income	Y_2	company's direct income

3.2. Sample data preprocessing

According to the "China Feed Listed Companies List", all the 16 listed feed companies in the list are taken as research samples, with data from the annual reports of each company in 2018-2020 and feed industry information network.

BCC model requires data to be non-negative and dimensional-consistent, so in order to meet the data should be standardized. The standardization method is as follows:

$$\begin{cases} \widehat{x_j} = \dfrac{x_j}{x_0}, j=1,2,\dots,n \\ \widehat{y_j} = \dfrac{y_j}{y_0}, j=1,2,\dots,n \end{cases}$$

Where the x_j is the sample independent variable data, the $\widehat{x_j}$ is the value of the standardized sample independent variable, the y_j is the sample dependent variable data, and the $\widehat{y_j}$ is the value of the standardized sample dependent variable.

4. Empirical Analysis

4.1. Analysis of DEA model results

The above input-output index data of 16 Chinese listed feed companies from 2018 to 2021 were selected and imported into DEAP2.1 to calculate according to BCC model. The calculation results are shown in Table 2.

From the perspective of considering the epidemic factors, the following conclusions are drawn by analyzing the changes in the operating performance of each company:

(1) The operating performance of He Feng, Da Beinong and Zheng bang before and after the outbreak of the epidemic reached DEA effectiveness, indicating that the epidemic did not affect the operating performance of the three companies, and they always maintained reasonable allocation of resources. Jingji Zhinong and Bai Yang, two listed feed companies as a whole, maintained good operating performance, only in a few years did not achieve operational performance DEA effective.

(2) Jin Xinnong and Tian Bang feed the operating performance of listed companies in 2018 annual DEA effective, but after 2018, pure technology and scale efficiency of the two companies were invalid, and showed that since 2019 the two companies were unreasonable resource allocation and management mechanism, but the scale effect was poorer; everything may be affected

Table 2: 2018-2021 Operational Performance Evaluates on Values of Listed Feed Companies

enterprise	Overall efficiency				pure technical efficiency				scale efficiency				returns to scale			
	2018	2019	2020	2021	2018	2019	2020	2021	2018	2019	2020	2021	2018	2019	2020	2021

Hai Da	0.335	0.102	1.000	0.745	0.483	0.360	1.000	1.000	0.694	0.284	1.000	0.745	irs	irs	-	drs
Bai Yang	1.000	1.000	1.000	0.791	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.791	-		-	irs
He Feng	1.000	1.000	1.000	0.383	1.000	1.000	1.000	0.407	1.000	1.000	1.000	0.940	-		-	irs
Da Beinong	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-		-	-
Ao Nong	0.748	1.000	1.000	0.361	1.000	0.000	1.000	0.409	0.748	0.000	1.000	0.884	drs	-	-	irs
Tian Ma	0.550	1.000	0.496	1.000	1.000	1.000	1.000	1.000	0.550	1.000	0.496	1.000	irs	-	irs	-
Jin Xinnong	1.000	0.423	0.138	0.199	1.000	0.561	0.235	0.425	1.000	0.753	0.588	0.468	-	irs	irs	irs
Jinji Zhinong	1.000	0.250	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.250	1.000	1.000	-	irs	-	-
Pei Ti	0.255	0.786	0.020	0.706	0.407	1.000	0.054	0.915	0.626	0.786	0.370	0.771	irs	drs	irs	irs
Tang Renshen	0.354	0.923	1.000	0.779	1.000	1.000	1.000	0.851	0.354	0.923	1.000	0.916	irs	irs	-	drs
Tian Bang	1.000	0.345	0.539	0.637	1.000	0.269	0.071	0.678	1.000	1.286	0.763	0.941	-	-	irs	irs
Tian Kang	0.307	0.409	0.891	0.867	0.494	0.427	0.939	1.000	0.622	0.958	0.949	0.867	irs	irs	drs	irs
Xin Xiwang	0.050	0.898	0.249	0.425	0.523	1.000	0.275	1.000	0.095	0.898	0.909	0.425	irs	drs	irs	drs
Zheng Bang	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-		-	-
Zheng Hong	0.997	1.000	0.005	1.000	1.000	1.000	0.047	1.000	0.997	1.000	0.108	1.000	irs	-	irs	-
Zhong Chong	0.336	1.000	0.523	1.000	0.489	1.000	1.000	1.000	0.687	1.000	0.523	1.000	irs	-	irs	-
mean	0.683	0.759	0.679	0.743	0.837	0.789	0.726	0.855	0.773	0.821	0,794	0.859				

Note: "drs" is diminishing returns to scale, "irs" is increasing returns to scale, "–" is constant returns to scale.

by disease and so on various aspects, the company's performance had deteriorated year.

(3) Tian Ma, Zhong Chong and Zheng Hong, the three company were rainbow DEA effective business performance in 2019, but affected by the outbreak, the operating performance of three company had not reached DEA effective in 2020 that Tian Ma and Zhong Chong were affected less and only their scale effective was invalid, the management mechanism of the effect is well,

While Zheng Hong was affected the most, resulting in the inefficiency of both pure technology and scale.

(4) Pei Ti, Xin Xiwang and Tian Kang had always been in the invalid DEA status of business performance, indicating that these companies always had problems in management and resource allocation, especially in the wake of the epidemic.

(5) Outbreak of the new champions league, under the influence of the comprehensive efficiency of the sample company mean and the mean average pure technical

efficiency and scale efficiency decreases, but the rebound in 2021, affected by the epidemic, feed the operating performance of listed companies in our country overall declined obviously, but with the outbreak of control, after the outbreak time feed also improved the performance of listed companies in our country. However, it can be seen from the results of return to scale of business performance that only a small number of listed feed companies had reduced returns to scale, while the rest of the companies had not suffered a large negative impact on return to scale. It showed that although the epidemic situation had affected the performance of listed feed companies, the company's performance can be improved as long as the company's management policy was properly adjusted and reasonable investment was appropriately increased.

4.2. Tobit Model Analysis

4.2.1. Model Construction

Comprehensive efficiency value 0~1obtained by the DEA method is in the middle range and has the characteristics of data truncation, in order to further explore the factors affecting the business performance of Chinese listed feed companies, the Tobit model was constructed to conduct regression analysis on the factors affecting the business performance of Chinese listed feed companies. Taking the comprehensive efficiency value as the dependent variable Y, the ratio of technical personnel to total employees, the ratio of R&D investment to operating income and the ratio of main business cost to main business income as independent variables, the standard Tobit model is further refined as follows:

$$Y_k = c + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \mu$$

Where, the Y_k represents the comprehensive efficiency value, the X_1 represents proportion of technical personnel in total employees, the X_2 represent proportion of R&D investment in operating income, the X_3 represents proportion of main business cost in main business income, the c represents constant term, the μ is error term, and the β_1、β_2、β_3 are coefficient of influencing factors. The collected sample data is imported into EViews software for Tobit regression analysis. The regression results are shown in Table 3-Table 6.

Table 3: Tobit regression results in 2018

variable	Correlation coefficient	standard error	T value	P value
X_1	1.637277	2.44562	0.66947 3	0.00 5
X_2	-4.508308	9.94218		0.00
X_3	0.101074	0.55532	-	
		4	0.45345 0.18200 9	6 0.00 8

2018 Tobit model:

$$Y = 0.563382 + 1.637277X_1 - 4.50831X_2 + 0.101074X_3$$

Table 4: Tobit regression results in 2019

variable	Correlation coefficient	standard error	T value	P value
X_1	0.543791	1.025592	0.530221	0.006
X_2	-2.646198	9.000358	-0.29401	0.007
X_3	1.200535	0.349988	3.430222	0.005

2019 Tobit model:

$$Y = -0.14188 + 0.543791X_1 - 2.6462X_2 + 1.200535X_3$$

Table 5: Tobit regression results in 2020

variable	Correlation coefficient	standard error	T value	P value
X1	3.692492	2.906172	1.270569	0.022
X2	-31.94487	17.20238	-1.85700	0.008
X3	-0.574126	0.477273	-1.20293	0.002

2020 Tobit model:

$$Y = 1.253958 + 3.692492X_1 - 31.94487X_2 - 0.574126X_3$$

Table 6: Tobit regression results in 2021

variable	Correlation coefficient	standard error	T value	P value
X_1	2.212883	2.271486	0.974201	0.349 2
X_2	10.36299	15.34011	0.675549	0.512 1
X_3	-0.101087	0.331765	-0.304694	0.765 8

2021 Tobit model:

$$Y = 0.59458 + 2.212883X_1 + 10.36299X_2 - 0.101087X_3$$

4.2.2. Analysis of results

Based on the analysis of the above results, it can be concluded that: (1) proportion of technical personnel to full staff was directly proportional to the company's business performance, and the proportion of technical personnel to full staff had a positive impact on the company's business performance before and after the epidemic; (2) The ratio of R&D investment to operating revenue was negatively correlated with operating performance in the first three years, and the negative correlation coefficient was greater in 2020 when the epidemic occurred. However, R&D investment had a positive impact on operating performance in 2021 when the epidemic was under control. (3) In the two years before the outbreak of the epidemic, the ratio of operating cost to operating revenue positively affects operating performance, while in the two years after the outbreak, operating cost negatively affects operating performance.

5. CONCLUSIONS

This paper uses the DEA-Tobit model to evaluate and analyze the operating performance of 16 Chinese listed feed companies from 2018 to 2021 and the influencing factors, and draw the following conclusions:

From the analysis of DEA efficiency values, (1) On the background of the global outbreak of the epidemic, the average comprehensive efficiency, pure technical efficiency and scale efficiency of the sample companies had all decreased, indicating that the operating performance of Chinese listed feed companies were greatly affected by the epidemic downtrend. (2) From the perspective of the return to scale of the company's operating performance, only the return to scale of Tian Kang was decreasing, and the return to scale of other companies had not been negatively affected. It shows that although the epidemic has affected the performance of listed feed companies, as long as the company's business policy is adjusted in time and reasonable investment is appropriately increased, the company's business performance can be improved and the current sluggish development of the feed industry can be changed.

From the analysis of the influencing factors of Tobit regression, (1) According to the regression results, it can be seen that the proportion of technical personnel to full-time employees has a positive impact on business performance, and the positive coefficient is greater after the outbreak, indicating that technical personnel have played a role in promoting the development of the company. More technical talents should be introduced to increase the company's operating performance; (2) R&D spending accounts for the proportion of revenue present negative correlation with the company's performance

shows that R&D input is very important for company, but due to the particularity of feed company R&D investment rate of return is low or even negative rate of return, as well as the background, the outbreak of an epidemic of feed industry development, Some feed companies can only guarantee the basic operations of the enterprise, therefore, for the feed companies improve the precision of R&D are important, but the outbreak under control, in 2021, R&D played a positive role in business performance, because of the outbreak, the epidemic has been effectively controlled, but the outbreak of abroad is still grim, feed companies in the import of raw materials uncertainty, and because of the particularity of the feed industry, its research and development mainly lies in the formula above, so in the supply chain instability, the replacement of new feed raw materials development is particularly important; (3) After the outbreak of the epidemic, the ratio of operating costs to operating income of listed feed companies is negatively correlated with the company's operating performance, indicating that the ratio of operating costs to operating income has had a negative impact on the company's operating performance under the background of the epidemic, so it should be Reasonable control of the proportion of operating costs to operating income in order to improve operating performance.

6. SUGGESTIONS

Through the analysis of the above results and the current situation of my country's listed feed companies, the following suggestions are put forward:

(1) Adjust the company's business policy in a timely manner. In the context of the global imported raw materials for feed and logistics and transportation have also been hindered accordingly, resulting in a downward trend in the operating performance of my country's listed feed companies.

(2) Appropriate introduction of technical personnel. The proportion of technical personnel to total employees showed a positive correlation with the impact of listed feed companies on the operating performance that did not be influenced by the outbreak of epidemic. Therefore, when the listed feed companies are recruiting employees, appropriate introduction of technical personnel can increase the operating performance of my country's listed feed companies.

(3) Improve the precision of R&D investment. According to Tobit regression model, the ratio of R&D investment to operating revenue has a negative impact on the feed company's operating performance, especially under the impact of COVID-19, the ratio of R&D investment to operating revenue has a greater negative impact on operating performance, so the accuracy of R&D investment is particularly important. In the context

of the epidemic, the overall development of the feed industry is not very good, so the company should improve the accuracy of R&D investment, increase R&D investment in line with the enterprise development strategy, reduce liquid assets, avoid negative rate of return, so as to unnecessary R&D investment, rational control of improve the company's business performance.

(4) Strictly control operating costs. The outbreak of the new crown epidemic has led to a sharp increase in the cost of feed companies in the procurement of raw materials. The proportion of the company's operating costs to operating income has a negative correlation with the company's operating performance. The company should strictly control operating costs to ensure the company's good operation to avoid the occurrence of bankruptcies in which the operating costs are too high, resulting in losses or even insolvency of the company

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