Research on Efficiency Evaluation of Agricultural Products Logistics Based on DEA Model in MAOMING City, Guangdong Province

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Abstract. This paper adopts the data input and output indicators from 2011-2020, and use Data Envelopment Analysis (DEA) to calculate the overall efficiency, technical efficiency and scale efficiency of agricultural products logistics in MAOMING, a city of GUANGDONG province, and then evaluate the efficiency of agricultural products logistics in MAOMING city in recent years, in order to offer reference to promote the efficiency of logistics.

Keywords: Agricultural Logistics; Data Envelopment Analysis; Logistics efficiency

1 INTRODUCTION

In 2016, the First document of the Central Committee of the COMMUNIST Party of China on the Formulation of the 13th Five-Year Plan for National Economic and Social Development proposed that we should strengthen the construction of distribution facilities and markets for agricultural products, promote the integration of rural industries, and promote the sustained and rapid growth of farmers' income. In November of the same year, Guangdong province also issued relevant documents to constantly improve the circulation system of agricultural products. Efficient logistics of agricultural products is an important guarantee to solve the problem of selling and buying agricultural products and increase farmers' income. To strengthen the logistics of agricultural products, it is necessary to analyze its efficiency and influencing factors, so as to find the problems existing in logistics and take corresponding measures to promote the efficient circulation of agricultural products.

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2 LITERATURE REVIEW

In recent years, with the development of domestic e-commerce and the improvement of domestic transportation and logistics infrastructure, the logistics industry has gradually become an important part of economic development, and the word "efficiency" in the logistics industry has frequently appeared. At present, how to optimize logistics efficiency has become one of the research hotspots in logistics industry. Shepherd (1963) believes that logistics efficiency is the ratio between the total economic value of circulating products and the total cost consumed in the logistics process [1]. Wanke, P. F. (2012) identified variables that had a significant impact on the scale efficiency of Brazil's 3PL (third-party logistics) by applying two-stage DEA, and finally came to the conclusion that the establishment of supply chain coordination mechanism was conducive to the timely synchronization of logistics information and inventory information, which enable Brazil 3PL (third party logistics) to allocate resources (inputs) to customer needs more rationally [2]. M. J. Kilibarda (2016) used principal component analysis and data Envelopment analysis (PCA-DEA) to verify the relevant values of logistics efficiency in eight countries, ranked countries according to efficiency scores, and found that product quality indicators and logistics service quality indicators are important indicators affecting efficiency[3]. Huo Hongmin (2020) used DEA model to analyze and evaluate the comprehensive efficiency, pure technical efficiency and scale efficiency of logistics industry in 17 cities in Shandong Province from 2011 to 2017, and put forward corresponding suggestions [4]. Xie Caihong and Liu Yingu (2020) adopted DEA analysis method, based on the empirical evaluation of logistics efficiency in 18 provinces along the belt and Road from 2013 to 2017. The results show that 18 provinces along the belt and Road have the problem of resource waste, and suggestions are put forward to improve the construction of logistics infrastructure according to local conditions, reduce the waste of logistics resources in production, give full play to location advantages, and improve the intensity of logistics industry [5].

3 EMPIRICAL RESEARCHES

3.1 Research methods

DEA model is Data Envelopment Analysis (DEA), A non-parametric test method was first proposed by W. W. Cooper, E. Rhodes, A. Charnes and A. Charnes in 1978[6], the famous American operational researchers. DEA method can be used to evaluate the efficiency of multiple inputs and outputs, and the final efficiency evaluation result will not be affected by the difference of measurement units. As long as all decision-making units use the same measurement unit, the efficiency value can still be calculated. Secondly, the weight in DEA method is not affected by human subjective factors. Through the analysis of slack variables, the utilization status of resources in inefficient decision-making units can be further understood, and the improvement direction and size of inefficient resources can be proposed, so as to provide decision-makers with ways to improve efficiency.

3.1.1 Fixed scale return DEA model -- CCR model

CCR model is the first DEA model introduced by A. Charnes, W.W. Cooper and E. Rhodes in 1978.CCR model is used to measure total efficiency under the assumption that dMU is in a fixed scale return situation. CCR model is usually used to evaluate and analyze the technical effectiveness among decision units with constant return to scale, and it is the most basic model of DEA model.The formula is as follows:

$$\begin{cases} \min\theta = \theta^* \\ \sum_{j=1}^{n} \lambda_j x_j + s^- = \theta x_0 \\ \sum_{j=1}^{n} \lambda_j y_j - s^+ = y_0 \\ \lambda_j \geq 0, \\ j = 1,2,3, \dots, \dots n \\ s^+ \geq 0, s^- \geq 0 \end{cases} \quad \dots\dots \qquad \dots(1)$$

In the formula above, λ_j represents the weight coefficient, $s^+$and s^- represent relaxation variable and residual variable respectively, $x_j$and $y_j$represent input index and output index respectively.

The model is a constant return to scale model. In the Equation above, if $s^+ = s^- = 0$, it indicates that this decision unit is DEA effective, and the technology and scale of decision unit are effective.

If $\theta = 1$, but $s^+ \neq 0$ or $s^- \neq 0$, then the decision unit is weak DEA efficient.

If $\theta < 1$, $s^+ \neq 0$ and $s^- \neq 0$, it indicates that the decision unit is non-DEA efficient. It means the decision unit is neither technologically efficient nor scale-efficient.

3.1.2 The DEA model of variable scale return -- BCC model

BCC model is used to measure pure technology and scale efficiency, assuming that dMU is in variable return to scale. Among various basic models of DEA, BCC model is a more suitable method to evaluate the effectiveness of pure technical efficiency and scale efficiency. BCC model is a new DEA model proposed by A.Charnes and W. W. Cooper et al in 1985. BCC model adds a constraint condition on the basis of CCR model. The constraint condition and formula are as follows:

$$\sum_{j=1}^{n} \lambda_j = 1 \dots\dots\dots \qquad (2)$$

$$
\begin{cases}
\min\sigma = \sigma^* \\
\sum_{j=1}^{n} \lambda_j x_j + s^- = \sigma x_0 \\
\sum_{j=1}^{n} \lambda_j y_j - s^+ = y_0 \\
\sum_{j=1}^{n} \lambda_j = 1, \qquad \cdots\cdots\cdots \\
\lambda_j \geq 0 \\
j = 1,2,3,\ldots,\ldots n \\
s^+ \geq 0, s^- \geq 0
\end{cases} \tag{3}
$$

In the formula above, s^+ and s^- represent relaxation variable and residual quantity, x_j represents input index, $y_j$represents output index. $\lambda_j$represents weight coefficient.

When $\sigma = 1$, $s^+ = 0$ and $s^- = 0$, the decision unit is purely technical valid.

When $\sigma = 1$ but $s^+ \neq 0$ or $s^- \neq 0$, the weak DEA pure technology is valid.

When $\sigma < 1$, the decision unit DEA is invalid. It means that the technology is ineffective at this point.

This paper adopts the most common BCC model in DEA model, calculates and analyzes the overall efficiency, scale efficiency and pure technical efficiency of maoming agricultural products logistics, and summarizes the corresponding conclusions, so as to solve the problems existing in the development process of Maoming agricultural products logistics.

3.2 Index system

The investment index is mainly from the agricultural logistics fixed assets investment, agricultural logistics employees' number, freight car ownership three aspects. The output index comes from the freight volume of agricultural products and the total amount of agricultural products logistics. The specific indicator system is shown in Table 1.

Table 1: Input-output index system of agricultural products logistics in Maoming city

Indicator Type	Indicator Name	Unit	Description
Investment index	Investment in fixed assets of agricultural products logistics	100 million Yuan	including the investment in fixed assets of the whole society in transportation, storage and postal services
	The number of people who work in agricultural products logistics department	ten thousand people	Those who work in the departments of transportation, storage and postal services
	Freight car ownership	Piece	mainly refers to the number of trucks in the city
Output index	Freight volume of agricultural products	ten thousand tons	ncluding freight volume of land, water and air transportation
	Total value of agricultural products logistics	100 million Yuan	including the total value of transportation, warehousing and postal services

3.3 The Sources of Data

The data in this paper are taken from Maoming Statistical Yearbook from 2011 to 2020. In the corresponding statistical yearbook, the input index data represented by the investment amount of fixed assets in agricultural products logistics and the output index data represented by the freight volume of agricultural products are not statistically detailed. Therefore, the data in this paper are replaced by the fixed asset investment and employment numbers of transportation, warehousing and postal services.

3.4 Analysis of results

According to the formula (2) and formula (3) mentioned earlier, this paper calculated the efficiency evaluation value of agricultural products logistics in Maoming city from 2010 to 2019 by using DEAP2.1 software, and sorted out the calculation results as shown in Table 2.

Table 2: DEA calculation results of BCC logistics efficiency evaluation

year	Total efficiency	Pure technical efficiency	Scale efficiency	Type of scale benefit
2010	0.939	1.000	0.939	increasing
2011	1.000	1.000	1.000	stability
2012	0.996	1.000	0.996	increasing
2013	0.856	0.975	0.878	increasing
2014	0.802	1.000	0.802	increasing
2015	0.865	1.000	0.865	increasing
2016	0.868	0.998	0.870	increasing
2017	1.000	1.000	1.000	stability
2018	1.000	1.000	1.000	stability
2019	1.000	1.000	1.000	stability
average	0.933	0.997	0.935	stability

As can be seen from table 2, the average overall efficiency of agricultural products logistics in MaoMing city is 0.933. The average pure technical efficiency is 0. 997. The average scale efficiency is 0. 935. They all were greater than 0.9, and agricultural products logistics scale reward showed an increasing trend or stability. It means that the overall level of MaoMing city agricultural products logistics development is good, and the input-output ratio is more reasonable.

From the perspective of overall efficiency, the overall efficiency value equals to1 in the years of 2011, 2017, 2018 and 2019, which means that DEA is effective, and indicate that agricultural products logistics has developed well in recent years. The input has been fully utilized, and the overall development scale is consistent with the allocation of resources. In other years, the overall efficiency value is lower than 1, which means that DEA is invalid and the maximum output is not reached. The overall efficiency of agricultural products logistics decreased first and then increased, indicating that with the national attention to the circulation of agricultural products logistics and the development of national economy. Therefore, the input -output structure of agricultural products logistics in MaoMing is increasingly reasonable.

From the perspective of pure technical efficiency, the pure technical efficiency value in 2013 and 2016 is lower than 1, which may be mainly due to the decline of MaoMing agricultural products logistics input in these two years, and the technical efficiency value in other years is 1. In the past years, the imbalance between supply and demand resulted from the poor circulation links of agricultural products in MaoMing city. A large number of rotten agricultural products failed to sell due to the problem of the channel. Consumers had to buy agricultural products at high prices, which directly led to high circulation costs and failed to form scale effect. Scale efficiency increases in the years of 2010, 2012, 2013, 2014, 2015 and 2016, indicating that agricultural products logistics input is insufficient in these years. We can achieve higher output by appropriate additional input.

4 CONCLUSIONS

Based on the DEA model, this paper analyzes the input-output data of agricultural products logistics in Maoming from 2010 to 2019, and evaluates the efficiency of agricultural products logistics in Maoming. The result shows that maoming city agricultural products logistics development condition is good. In order to further improve the logistics efficiency of Maoming city, the allocation of resources in the input-output process should be further optimized, and logistics personnel should be further expanded. Moreover, related logistics policies and standards should be further improved.

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