Study on the evaluation of agricultural product logistics efficiency in Jilin province

Hongshen Yu\(^1\), Lihong Zhao\(^2\), Maoyang Wu\(^3\)

\(^1\)Changchun University of Finance and Economics, Changchun, China
\(^2\)Jilin Engineering Normal University, Changchun, China
\(^3\)Changchun University of Finance and Economics, Changchun, China

Corresponding author and e-mail: Lihong Zhao, 32387515@qq.com

Abstract. With a great variety of crop categories, Jilin Province is the main grain producing area in China, but agricultural product logistics is developing slowly. Based on the input-output data of agricultural product logistics in Jilin Province from 2009 to 2018, this paper conduct an empirical study on the efficiency of agricultural product logistics in Jilin Province with Deap2.1 software by means of CCR and BCC models in data envelopment analysis. The research results show that there are still some deficiencies in the investment of fixed assets and professionals etc. in agricultural product logistics in Jilin Province, and the scale effect has not yet been realized, and the overall capacity of agricultural product logistics is weak; This paper puts forward the reasonable allocation of input resources from the three levels of government, industry and logistics subjects, to improve the management level of agricultural product logistics and realize the cost reduction and efficiency increase.

1. Introduction
On March 5, 2015, Premier Keqiang LI stressed in the government work report that it was necessary to deepen the reform of the circulation system, strengthen the construction of modern logistics facilities such as large-scale wholesale, warehousing and cold chain of agricultural products, and strives to significantly reduce the circulation cost. The Central Document No. 1 in 2016 and General Secretary Xi Jinping's report in the 19th National Congress of CPC clearly pointed out that it was necessary to strengthen the construction of circulation facilities and market of agricultural products. Strategic Plan for Rural Revitalization (2018-2022) of China clearly pointed out that: "Accelerate the improvement of modern logistics system of agricultural products and build a safe, efficient and integrated operating agricultural products logistics network." Agricultural products are critical for the national economy and people's livelihood and whether the agricultural products logistics industry can develop healthily and efficiently, and play an important role in promoting the reform of agricultural supply side, increasing farmers' income and ensuring national food security [1-2]. As a major agricultural province and an important base of national commodity grain, Jilin Province adheres to the development strategy of establishing a province by agriculture, and undertakes the major political responsibility of ensuring national food security. Therefore, it is necessary to study the efficiency of agricultural products logistics in Jilin Province, and to seek ways to improve the efficiency, which is beneficial for promoting the long-term and sustainable development of agricultural products logistics.
industry in Jilin Province, realizing the rational allocation of agricultural resources, accelerating the
development of agricultural economy in Jilin Province, and ensuring the national food security.

2. Development status of agricultural product logistics in Jilin province
Jilin Province is located between 122-131 degrees east longitude and 41-46 degrees north latitude,
belonging to the temperate continental monsoon climate, with sufficient light and four distinct seasons;
Jilin Province covers an area of 18.73 million hectares, about 1/3 of which is cultivated land. The area
is vast, the soil is fertile and the water source is sufficient; Soil and climate conditions are very
suitable for crop growth [3-4]. In 2018, the added value of agriculture, forestry, animal husbandry and
fishery in Jilin Province increased by 2% year on year, reaching RMB 120.48 billion; The total output
of grain is 36.33 million tons, the total output of pigs, cattle, sheep and poultry is 2.517 million tons,
the output of vegetables and edible fungi is 4.3815 million tons, and the output of aquatic products is
234,100 tons [5-6]. Jilin Province has a large number of agricultural products. Excluding those for
farmers' self-sufficiency, the rest of agricultural products have entered the circulation field to meet the
needs of domestic and foreign consumers, which puts forward higher requirements for modern
agricultural product logistics.

In recent years, Jilin Provincial Government has attached great importance to the construction of
transportation facilities, and the operating mileage of railways and highways, etc. has increased year
by year. By 2018, the operating mileage of railways in the province has reached 4,876.75 km and the
total mileage of highways has reached 105,400 km, and the inland river navigation mileage has
reached 1,621 km [7]. At present, Jilin Province has initially formed a modern three-dimensional
transportation system with comprehensive development of sea, land and air. Moreover, this modern
dimensional transportation system is extending to rural areas, and the modernization
construction of agricultural product logistics is speeding up.

3. Empirical study on the efficiency of agricultural product logistics in Jilin province

3.1. Research methods
Data Envelopment analysis (DEA) was first proposed by American scholars: Charnes, Cooper and
Rhodes in 1978. It is a non-parametric technical efficiency analysis method based on the relative
comparison between the evaluated objects. In this method, the measure object of efficiency is called
decision-making unit (DMU). DMU can be any department or unit with measurable input and output,
such as manufacturers, schools, hospitals, project implementation units (regions), and individuals,
such as teachers and students, etc., which requires comparability between DMUs [8]. The main idea of
DEA is to study the comprehensive ratio of input and output of DMU. An effective production frontier
is determined by evaluating the weight of input-output factors of each unit. The distance from each
DMU to the production frontier is taken as the basis to judge whether DEA of DMU is effective. This
method has special advantages in the analysis of multiple inputs and multiple output, so it can be
widely used.

In DEA model system, CCR model based on invariable returns to scale and BCC model based on
variable returns to scale are most commonly used.

- DMU is denoted as DMU<sub>j</sub> = 1, 2, ..., n.
- Input vector is denoted as x<sub>ij</sub>, i = 1, 2, ..., m.
- Output vector is denoted as y<sub>rj</sub>, r = 1, 2, ..., s.
- Vector weight is denoted as λ<sub>j</sub> = 1, 2, ..., n.
- Input relaxation variable is denoted as s<sup>-</sup>.
- Output relaxation variable is denoted as s<sup>+</sup>.

The technical efficiency is denoted as θ

| CCR model | BCC model |
|-----------|-----------|

Table 1. Comparison between CCR model and BCC model.
\[
\begin{align*}
\text{min} & \quad \theta \\
\sum_{j=1}^{n} \lambda_j x_{ij} + s^- = & \theta x_{i0}, \quad i=1,2,\ldots,m \\
\sum_{j=1}^{n} \lambda_j y_{rj} - s^+ = & \theta y_{r0}, \quad r=1,2,\ldots,s \\
s^- & \geq 0; \quad s^+ \geq 0; \quad \lambda_j \geq 0; \quad j = 1,2,\ldots,n
\end{align*}
\]

When \( \theta = 1 \), and \( S^- = 0, \ s^+ = 0 \), the DEA of DMU is effective, and the technical efficiency is optimal.

When \( \theta \neq 1, \ S^- \neq 0, \ s^+ \neq 0 \), DMU is weak and DEA is effective, and technical efficiency is not optimal.

\( \theta_{\text{CCR}} \) represents the CCR efficiency value of the io DMU, which is the comprehensive efficiency or technical efficiency; \( \theta_{\text{BCC}} \) represents the BCC efficiency value of the io DMU, which is the pure technical efficiency. Comprehensive efficiency = pure technical efficiency \( \times \) scale efficiency. The scale efficiency can be obtained by the formula.

3.2. Selection of logistics efficiency measurement indicators

According to Cobb-Douglas production function, labor, capital and technology are the key factors affecting the output. Based on the research of scholars, this paper selects the number of employees in agricultural product logistics industry as labor input; the fixed assets investment amount of agricultural product logistics is selected as the capital investment of agricultural product logistics; because there is no unified index to measure technology in reality. In terms of output index, it is more intuitive and accurate to analyze the efficiency of agricultural product logistics from the perspective of logistics output value. It can reflect the value-added process. Therefore, this paper selects the added value of agricultural product logistics as the output index.

3.3. Data sources

This paper uses DEA model to conduct the empirical analysis for the efficiency of agricultural product logistics in Jilin Province, taking 2009-2018 as the observation period and ten years as the DMU in the model. The required data are mainly from the 2009-2018 China Statistical Yearbook, Jilin Province Statistical Yearbook, and 2009-2018 Social and Economic Development Statistical Bulletin of Jilin Province. In addition, it is impossible to directly obtain the relevant data of the number of employees in agricultural product logistics, fixed assets investment amount and added value of agricultural product logistics due to the lack of professional data statistics of agricultural product logistics industry. The method of data processing in existing literature is used and the total number of employees in transportation, warehousing and postal industry, fixed asset investment amount and added value of logistics industry are multiplied by N, where n is the proportion of residents’ consumption to total consumption.

3.4. Evaluation on logistics efficiency of agricultural products in Jilin Province
3.4.1. Analysis of comprehensive technical efficiency. Comprehensive technical efficiency can be used to evaluate the resource allocation ability and utilization efficiency of DMU. In this paper, it shows the efficiency value of agricultural product logistics in Jilin Province under the current technical and economic conditions. Table 1 shows that the comprehensive efficiency value of agricultural product logistics in Jilin Province is only 1 in 2011 and 2012, reaching DEA effectivity; it is less than 1 in other years, not reaching the production frontier and belonging to non-DEA effectivity. In the ten years from 2009 to 2018, the average value of comprehensive efficiency was 0.871. There were 8 years with non-DEA efficiency, and the comprehensive efficiency of 4 years was lower than the average value, which showed that the agricultural products logistics in Jilin Province was in an ineffective area for many years, and the effective utilization of resources was insufficient. Therefore, it is necessary to optimize the allocation of resources, change the traditional logistics mode, create green logistics, and make resource allocation more reasonable and give full play to the efficiency of resource utilization to the utmost extent to achieve DEA effectivity.

Table 2. Input-Output Evaluation Results of Agricultural Product Logistics Industry in Jilin Province from 2009 to 2018.

| Year | Comprehensive efficiency | Pure technical efficiency | Scale efficiency | Returns to scale |
|------|--------------------------|---------------------------|-----------------|-----------------|
| 2009 | 0.984                    | 0.986                     | 0.998           | Progressive increase |
| 2010 | 0.806                    | 0.875                     | 0.921           | Progressive increase |
| 2011 | 0.996                    | 1.000                     | 0.996           | Progressive increase |
| 2012 | 1.000                    | 1.000                     | 1.000           | Constant         |
| 2013 | 1.000                    | 1.000                     | 1.000           | Constant         |
| 2014 | 0.896                    | 1.000                     | 0.896           | Progressive increase |
| 2015 | 0.922                    | 1.000                     | 0.922           | Progressive increase |
| 2016 | 0.838                    | 0.920                     | 0.910           | Progressive increase |
| 2017 | 0.593                    | 0.596                     | 0.995           | Progressive increase |
| 2018 | 0.675                    | 1.000                     | 0.675           | Progressive decrease |
| Average value | 0.871          | 0.9377                   | 0.9313          |                 |

3.4.2. Pure technical efficiency analysis. Pure technical efficiency can be used to judge whether the current resource utilization is reasonable. It can reflect the reasonable degree of agricultural product logistics industry planning, supporting degree of transportation infrastructure construction, coordination of fixed assets investment proportion, high and low management level of employees and professional quality under the certain premise of fixed assets, labor force and transportation facilities construction in agricultural product logistics. As shown in Table 2 and Figure 1, the average pure technical efficiency of agricultural product logistics in Jilin Province is 0.9377. Compared with the comprehensive efficiency, it has a small difference with production frontier. There are six years with the pure technical efficiency value of 1 during the study period, accounting for 60% of the total number of samples, indicating that the overall level of pure technical efficiency of agricultural product logistics industry in Jilin Province is relatively high. In most years, the input level of agricultural product logistics meets the needs of industrial development, and achieves the ideal output state under the given input. However, the pure technical efficiency is not fully effective, the input utilization of
resources is not sufficient, input redundancy or insufficient output exists, and there is still a large space for the development of agricultural product logistics in Jilin Province.

3.4.3. Scale efficiency analysis. Scale efficiency can be used to analyze the matching degree of agricultural product logistics scale and input-output under the condition of certain pure technical efficiency. Table 2 shows that the average scale efficiency of agricultural product logistics from 2009 to 2018 is 0.9313, in which the annual scale efficiency with effective comprehensive efficiency is 1; In the years when the comprehensive efficiency is non-DEA effectivity, the pure technical efficiency is 1 in 2011, 2014, 2015 and 2018, that is to say, the non-DEA effectivity of scale efficiency is the main reason for the non-DEA effectivity of comprehensive efficiency. It also indicates that the scale of agricultural product logistics in Jilin Province does not match the input-output, especially in 2018, which is far from the optimal scale.

3.4.4. Analysis of returns to scale. Return to scale is used to analyze the proportional relationship between the change of production scale and the scale of output. The change of returns to scale can be divided into three situations: constant, progressive increasing and decreasing. The returns to scale of agricultural product logistics in Jilin Province show that the scale efficiency is 1 in 2012 and 2013, which is in the stage of constant returns to scale; Most of the other years are in the progressive increase stage of returns to scale, indicating that the development trend of agricultural product logistics in Jilin Province is good during the years, but the output scale is not optimal. It is advisable to properly increase the input of various input factors and expand the logistics market of agricultural products, strive to improve the output of agricultural products, accelerate the turnover of agricultural product logistics, and quickly reach the state of scale economy; It is in the progressive decrease stage of returns to scale in 2018, indicating that too much input of one or more factors will lead to waste of resources. Therefore, it is necessary to strengthen the management of input factors to improve the efficiency of agricultural product logistics.

4. Way to improve the efficiency of agricultural product logistics in Jilin Province
As shown in Figure 1, based on the ten-year data analysis of Jilin Province from 2009 to 2018, it is found that the comprehensive efficiency, pure technical efficiency and scale efficiency are all improved first and then decreased, with large fluctuation range, indicating that the agricultural product logistics efficiency of Jilin Province is not high, and it belongs to extensive development, and the input resources have not been rationally utilized, and scale effect has not yet formed.
The main reasons are as follows: First of all, although the business entity of agricultural product logistics in Jilin Province has a high degree of diversification, including state-owned enterprises, collective enterprises, private enterprises and foreign-funded enterprises, etc., there are less production entities and more sales logistics entities of agricultural product logistics. At present, it is seriously insufficient in the development of third party logistics of modern agricultural products in Jilin Province, which is mainly based on independent management. There are various marketing channels for agricultural products in Jilin Province. Logistics enterprises have not yet formed alliance for cooperative development with agricultural trade market, wholesale market, processing and sales enterprises and agricultural economic cooperation organization, so scale effect has not formed.

Secondly, as one of the important commodity grain bases in China, Jilin Province has been given great support and capital supply by the state in terms of the grain development and grain circulation resources construction in Jilin Province, and the agricultural product logistics has developed greatly. However, the infrastructure of agricultural product logistics in Jilin Province is still relatively backward, and the commodity circulation is still in the form of natural logistics and normal temperature, with a high loss rate; agricultural product logistics channels and processes are not standardized; It is impossible to implement mechanized operations in grain storage; The degree of informatization and specialization of agricultural product logistics is still not high. Therefore, the agricultural product logistics in Jilin Province is still in the traditional logistics stage, and the logistics efficiency is low, and it has not realized the effective allocation of agricultural resources, and it is difficult to ensure food security.

It can be seen that agricultural product logistics in Jilin Province not only needs to improve the logistics management technology level, but also needs to form scale effect. The specific promotion way is as follows:

4.1. Give Full Play to Government Functions
The first is to further optimize the industrial structure. Adjust and upgrade the internal structure of agriculture through deepening the "supply side" reform, so as to improve the efficiency of agricultural product logistics.

The second is to accelerate the construction of government logistics information sharing platform. The e-government information that can be disclosed by the departments of transportation, taxation, industry and commerce should be integrated and made public to the public, so as to facilitate the people and benefit the enterprises. Promote the construction of regional logistics information platform, encourage the information sharing of regional logistics platform, so as to promote the coordinated development of agricultural product logistics industry in Jilin Province.

The third is to accelerate the improvement of logistics infrastructure. Relying on the "761" Project Plan for New Infrastructure Construction in Jilin Province, focus on renovating the "unsmooth return" rural roads and constantly upgrade the logistics infrastructure; Strengthen the application of advanced cold chain equipment, encourage qualified cold chain logistics enterprises to reasonably plan and construct cold chain facilities for preliminary processing such as precooling, storage and preservation in the origins of fresh agricultural products, so as to improve the logistics quality of agricultural products.

The fourth is to cultivate professional logistics talents. Optimize the talent structure of agricultural product logistics, encourage colleges and enterprises to cultivate a number of talents specialized in agricultural product logistics; Promote investment and attract technical personnel through preferential policies, and improve the management technology level of Jilin Province's own agricultural product logistics industry.

4.2. Strengthen the Role of Industry Associations
Give full play to the main role of industry associations in the formulation of logistics standards, and formulate industry standards together with industry associations and enterprises. Actively promote the application of modern information technology and cold chain logistics standard projects of fresh
agricultural products with special financial funds, and guide enterprises to develop into regular cold chain logistics of agricultural products. Strengthen the training, publicity, promotion and application of agricultural products cold chain logistics standards, enhance the service standardization awareness of agricultural product logistics enterprises, promote demonstration enterprises to formulate operation and management specifications higher than the current national and industrial standards, and drive the publicity, promotion and implementation of relevant standards of agricultural products cold chain logistics through pilot demonstration.

4.3. Mobilize the Initiative of Logistics Subject
The first is to strengthen large-scale operation and cultivate leading enterprises. Optimize the organization mode of agricultural products supply chain, cultivate agricultural cooperatives, Internet platform and supply and marketing cooperatives to become the subjects of agricultural products circulation, and realize the integrated operation of "marketing+ production" or "production + marketing". Integrate the existing rural convenience stores and postal and other resources for utilization, establish a rural express cooperative platform, centralize the collection and delivery, improve the efficiency of agricultural product logistics and realize the scale effect of agricultural product logistics.

The second is to strengthen the application of digital technology. agricultural product logistics enterprises should strengthen the application of advanced information technology, such as big data, Internet of things and mobile Internet, accurately grasp the market demand, scientifically and reasonably formulate the plan of goods preparation by separate warehouse, reasonably plan the logistics route scheme, reduce the logistics cost and improve the overall efficiency of agricultural product logistics chain.

5. Conclusions
The reform of agricultural supply side can be promoted by improving the efficiency of agricultural product logistics. It is also an important way to solve the "three rural" problems. Taking DEA model as the evaluation model of agricultural product logistics efficiency in Jilin Province, this paper establishes the input and output index system of agricultural product logistics efficiency evaluation, analyzes the data from 2009 to 2018, and puts forward the sustainable development suggestions from macro, meso and micro levels, i.e., laying emphasis on the utilization efficiency of agricultural product logistics resources and considering the matching of industrial scale and demand, which provides a new idea and method for the quantitative evaluation and optimization of agricultural product logistics efficiency. However, there are also some deficiencies in this paper, such as the incomplete selection of input and output indexes, the lack of horizontal evaluation of cities in Jilin Province, and so on. Therefore, more efforts will be made in this aspect in the future.

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References
[1] Chun FU, Huanrui OUYANG, Xueru ZHAO. Green development efficiency measurement and evaluation of Jiangxi Province Based on DEA and Malmquist index model [J]. Ecological Economy, 2020, 36 (06): 51-57+172.
[2] Kaixin GAO, Mingchang CHU. Research on Efficiency Evaluation of Logistics Industry in Liaoning Province Based on DEA-BCC [J]. Journal of Liaoning University of Technology (Natural Science Edition), 2020, 40 (03): 170-172.
[3] Kang GAO, Bukuo ZHANG, Maochun WANG, Nan ZHAO. Research on Spatial Pattern and
Difference of Logistics Efficiency in Western China Based on Super Efficiency DEA-ESDA [J]. Areal Research and Development, 2019, 38 (06): 6-10.

[4] Xiong ZHOU, Fang ZHENG. Evaluation on the Logistics Efficiency of Agricultural Products in Fujian [J]. Journal of Fujian Agriculture and Forestry University (Philosophy and Social Sciences), 2018, 21 (03): 19-23.

[5] Donghua LIU, Junjie LI, Liang CHEN. Evaluation on Innovation Efficiency of Industrial Ecological Technology in China -- Based on the provincial panel data from 2011 to 2014 [J]. Journal of Jilin College of Finance and Taxation, 2017, 33 (01): 5-13.

[6] 2015 Work Report of the Central People's Government of the People's Republic of China

[7] Ling CHEN. Measurement of Provincial Agricultural Produce Logistics Efficiency Based on Improved DEA [J]. Logistics Technology, 2014, 33 (21): 288-291.

[8] Manzhi LIU, Meihua ZHOU, Juan YANG. Urban Logistics Efficiency Evaluation Model and Empirical Study Based on DEA [J]. Statistics & Decision, 2009 (06): 50-52.