# Performance evaluation on agricultural product input/ output logistics management in China

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## Abstract

Commercialization in past years results in population concentrating in cities, has agricultural production gradually approach marginalization and regionalization, and increases the distance between agricultural production and marketing. In face of global competition, it also encourages the modernization of agricultural management. The establishment of agricultural strategy coalition and agricultural distribution centers is therefore largely promoted in past years. Supply chain logistics orientation is also emphasized in agriculture. Agricultural products stress on freshness and rapidness as they are perishable and hard to store. Rapidness therefore is emphasized in supply chain logistics. DEA is applied to the performance evaluation of agricultural product logistics in this study, and Modified Delphi Method is used for screening inputs and outputs. Total 4 inputs/outputs are selected in this study, and cities in Shanghai are taken as the samples. The research results show that 1 DMU reveals strong efficiency on agricultural products logistics, 5 DMUs present the efficiency in 0.9-1, and 7 DMUs appear the efficiency lower than 0.9. Furthermore, returns to scale analysis and slack variable analysis are applied to measure the improvement for excessive and short inputs. According to the results to propose suggestions, it is expected to develop the maximal effectiveness of agricultural product supply and marketing, complete integrated and diversified agricultural product supply and marketing, and promote the added value of agricultural products.

**Keywords:** Agricultural products. Logistics. Supply chain. Performance evaluation.

## 1. Introduction

The government introducing high-tech industries, such as integrated circuit and foundry, in past years has created national economic miracle, but resulted land fighting between agriculture and industry, produced pollution and waste, exhausted energy, and

destroyed the ecology. Commercialization results in population concentrating in cities, has agricultural production gradually approach marginalization and regionalization, and enlarges the distance between agricultural production and marketing. An agricultural production and marketing system is complicated and composed of various layers. Agricultural products create the profits of various intermediary sellers but form various problems. When national unemployment rate increases, the agriculture population would be relatively enhanced. Rural areas always play the primary role to buffer unemployed population and settle social order. Agriculture is the basis of a nation that the consideration of agricultural strategic location is also important. People have to rely on food for the survival. It is regarded as an extremely important issue and task to develop agriculture under the situation of bread being the staff of life, expand agricultural marketing markets, and assist in the development of agriculture.

In face the global competition, it is encourage modernizing agricultural management to cope with the impact of WTO on agricultural products. There are high-level agricultural technology foundation, high-level information and electronics industries, and modernized logistics channels domestically, while an efficient organization to promote the establishment of new systems and apply knowledge innovation to replace out-of-date marketing is short. The establishment of agricultural strategy coalition and agricultural distribution centers are therefore largely promoted, and supply chain logistics orientation is also extremely emphasized in agriculture. Products are normally concentrated in local wholesale markets and then directly delivered to consumption places. However, few farmers would outsource logistics (e.g. freight transport companies, delivery service).

In consideration of costs and expenses for agricultural products, it would be more economical to concentrate the products in wholesale markets for transportation. Agricultural products stress on freshness and rapidness, as they are perishable and hard to store. Rapidness is therefore emphasized in supply chain logistics. Aiming at agricultural product logistics, the performance is evaluated in this study, expecting to transform traditional supply and marketing problems with innovative logistics concepts, concentrate local agricultural resources to expand agricultural product logistics management, maximize the effectiveness of agricultural product supply and marketing, complete integrated and diversified agricultural products, and promote the added value of agricultural products.

## 2. Literature Review

### 2.1. Agricultural logistics

He et al. (2016) mentioned the definition of logistics in The International Society of

Logistics as the planning, execution, and process control to efficiently and effectively store and deliver raw materials, work in process, finished goods, and the relevant information between manufacturing ends and consumer ends to measure up to customer demands.

Orjuela-Castro et al. (2017) indicated that logistics was responsible for the design and management of the entire system to control the move of raw materials, semi-finished products, and stocks and the geographic strategic disposal. Benartzi et al. (2017) pointed out logistics as delivering correct quality of products, under good conditions, to correct places at proper time, charging reasonable prices, and providing real-time information, which were considered as the value of logistics that it was gradually emphasized in the society.

Tra & Charles (2016) defined agricultural logistics as the activity from agricultural products being produced and delivered to consumers, including the transportation, temporary storage, grading, packaging, processing, and information exchange of agricultural products. DeVellis (2016) explained that it required the operation of various distributors and marketing organizations to deliver agricultural products from the place of origin to consumers; the consumption behaviors among farmers, distributors, marketing organizations, and consumers would consist of the so-called marketing logistics system. Mishra et al. (2016) revealed that agricultural logistics contained order processing, incoming processing, agricultural processing, packaging processing, shipping processing, and return goods processing of vegetables & fruits and grains. Cahyadi & Hermann (2016) regarded agricultural chain as the supply chain of products, which were crops or being processed to become agricultural processed products. Ghezavati et al. (2017) indicated that agricultural products, with special quality characteristics, should be carefully considered the transportation and storage processes. In an agricultural chain, it would have to pay for refrigeration, air-conditioner temperature control, or sun exposure prevention to maintain the product quality.

### 2.2. Logistics performance

Mu & Pereyra-Rojas (2017) stated that domestic logistics performance indicators were divided into logistics environment & facilities report and logistics performance report, mainly providing the country for the evaluation to compare the logistics efficiency among countries. Xiao et al. (2017) pointed out six dimensions for domestic logistics performance indicators, namely logistics service charge level, infrastructure quality, service and quality of logistics capacity, core logistics process efficiency, major source delay, and logistics environment change since 2005. The factors were described as below: (a) Logistics service charge level:

including port charges, airport charges, highway costs, railway transportation rate, warehousing fees, and agency (office) fees (Corsi & Novelli, 2016); Infrastructure quality: containing port, airport, highway, railway, warehouse, and telecommunication equipment; (b) Service and quality of logistics capacity: covering highway, railway, air transport, sea transport, warehouse, freight, customs, inspection organization quality/standard, health/plant inspection organizations, customs broker, trade and transportation association, consignee/consignor (Spradley, 2016); (c) Core logistics process efficiency: including import clearance and delivery, export clearance and delivery, customs clearance, sufficient and timely message on regulation changes, and expedite clearance of traders abiding regulations; (d) Major source delay: containing warehouse, pre-shipping inspection, maritime transport, criminal behavior, and informal fundraising; (e) Logistics environment change since 2005: covering various standard Chinese/English explanations: customs clearance process, other clearance process, trade and transportation related infrastructure, telecommunication and communication infrastructure, private logistics service, logistics regulations, incidence of corruption (Etemadnia et al., 2015).

### 2.3. Data Envelopment Analysis

Data Envelopment Analysis, first appearing in the article published by Charnes, Cooper, and Rhodes in 1978 (Stoica et al., 2015), is a non-parametric method. That is, without default production function, multiple inputs and multiple outputs of decision making units could be calculated, with the linear-planning mathematical operation, the points on the production frontier, which economically refers to the input/output combination mostly advantageous to the decision making units, i.e. relatively efficient units; such efficient units are connected to consist of the efficiency frontier, i.e. envelope. Furthermore, the relative efficiency of decision making units and the improvement direction to achieve efficiency could be measured by comparing the observation value of input/output ratio with the efficiency frontier. Chen et al. (2018) organized the systematic application of Data Envelopment Analysis into four major steps: (I) Definition and selection of decision making units: Decision making units are the evaluated objects in Data Envelopment Analysis. To have the decision making units being evaluated at the same foothold, the homogeneity should be confirmed, i.e. operation under same goals, executing similar work, and under same market conditions. Regarding the number of decision making units, An et al. (2015) proposed the empirical law that the number of decision making units should be at least twice of the sum of inputs and

outputs; (II) Selection of input/output: Inputs/outputs are closely correlated to the evaluation of the relative efficiency of decision making units that the selection should be based on the business characteristics of decision making units and confirm the business objectives. The selected inputs/outputs should be tested the correlation, i.e. isotonicity between inputs and outputs, revealing that outputs could not be reduced when increasing inputs; (III) Selection of evaluation model: The selection of evaluation model depended on the research objectives and the information required for decision making; (IV) Analysis and explanation of result: The Data Envelopment Analysis result should be able to explain the performance of decision making units and provide suggestions for improvement as the reference for decision makers. For this reason, the analysis result should cover efficiency analysis and slack variable analysis and provide management suggestions.

## 3. Research design

DEA is applied in this study to evaluate the performance of agricultural product logistics, where proper inputs and outputs should be selected to efficiently evaluate the system performance of DMUs. To combine the selection of input/output with expert opinions, reduce input costs, and avoid fuzziness in the survey process, Modified Delphi Method is applied to select inputs and outputs. Total 35 copies are distributed for this study, and 22 valid copies are retrieved, with the retrieval rate 63%. Researchers indicate that the public opinions with more than 5 participants could be the analysis reference. Besides, the interviewed experts cover industry, official, and academia and show frequent interaction with agriculture to present certain representativeness.

After the operation with Modified Delphi Method, the geometric mean is used as the consensus of experts to evaluate inputs and outputs, and the median of the evaluation scores is regarded as the selection standard to select inputs and outputs which are able to evaluate the performance on agricultural product logistics. Total 4 inputs/outputs are selected for this study, and cities in Shanghai are taken as the samples. Total 13 DMUs are available. The variable data in this study are acquired from public prospectuses and annual reports.

Definition of variable:

I. Inputs: (1) Facility cost: referring to expenses invested in agricultural logistics facilities.

II. Outputs: (1) Efficiency: delivery time to implement an order. (2) Profit: income acquired after selling agricultural products.

## 4. Empirical Analysis of Agricultural Product Logistics

### 4.1. Agricultural products logistics efficiency analysis

The efficiency evaluation results through DEA could help understand the efficiency of agricultural product logistics. Efficiency=1 stands for the DMU being relatively efficient; on the contrary, efficiency<1 indicates the DMU being relatively inefficient. The empirical results, Table 1, reveal 1 city being relatively efficient, with the efficiency=1, that the agricultural product logistics reaches the ideal state; the rest cities are comparatively inefficient.

**Table 1: Relative efficiency of cities**

| City | overall efficiency | pure technical efficiency | scale efficiency |
|---|---|---|---|
| Nanjing | 0.99 | 0.98 | 0.99 |
| Suzhou | 1.00 | 1.00 | 1.00 |
| Xuzhou | 0.96 | 0.96 | 0.97 |
| Nantong | 0.88 | 0.87 | 0.88 |
| Yancheng | 0.85 | 0.84 | 0.85 |
| Wuxi | 0.94 | 0.95 | 0.94 |
| Huaian | 0.83 | 0.82 | 0.83 |
| Taizhou | 0.91 | 0.91 | 0.91 |
| Suqian | 0.80 | 0.81 | 0.80 |
| Changzhou | 0.77 | 0.76 | 0.77 |
| Yangzhou | 0.92 | 0.93 | 0.92 |
| Lianyungang | 0.73 | 0.72 | 0.73 |
| Zhenjiang | 0.82 | 0.82 | 0.82 |

### 4.2. Slack variable analysis

In terms of returns to scale analysis, Table 2, 1 city presents constant returns to scale, with the agricultural products logistics efficiency achieving the optimal, while the rest 12 cities appear increasing returns to scale, showing that they could expand the scales to enhance the marginal returns and further promote the efficiency. In regard to slack variable analysis, the improvement for excessive and short inputs of cities is shown in Table 2. Such cities could reach efficient agricultural product logistics by reducing excessive inputs and increasing short inputs.

**Table 2: Relative efficiency of cities**

| decision making unit (DMU) | improvement of input | improvement of output | | returns to scale |
|---|---|---|---|---|
| | facility cost | efficiency | profit | |
| Nanjing | 0 | 1 | 0 | IRS |
| Suzhou | 0 | 0 | 0 | CRS |
| Xuzhou | 1 | 0 | 1 | IRS |
| Nantong | 1 | 1 | 1 | IRS |
| Yancheng | 2 | 2 | 1 | IRS |

| | | | | |
|---|---|---|---|---|
| Wuxi | 1 | 2 | 0 | IRS |
| Huaian | 2 | 2 | 0 | IRS |
| Taizhou | 0 | 2 | 1 | IRS |
| Suqian | 3 | 2 | 0 | IRS |
| Changzhou | 4 | 3 | 3 | IRS |
| Yangzhou | 1 | 2 | 1 | IRS |
| Lianyungang | 5 | 4 | 3 | IRS |
| Zhenjiang | 3 | 2 | 0 | IRS |

Data source: Self-organized in this study.

## 5. Conclusion

Researchers classify DMUs into strong efficiency, marginal efficiency, marginal inefficiency, and obvious inefficiency. DMUs with strong efficiency, with the efficiency=1 and the slack variable=0, largely outperform inefficient DMUs. Such DMUs could maintain the efficiency, unless there are major changes in inputs and outputs. Marginal efficiency shows the efficiency=1 and at least one slack variable not being 0. Such DMUs would reduce the efficiency below 1 by increasing inputs or reducing outputs. Marginal inefficiency reveals the efficiency between 0.9 and 1, and the efficiency could be easily increased to 1. DMUs with the efficiency lower than 0.9 are obviously inefficient. Such DMUs could hardly become efficient in short term. Those appear the efficiency lower than 0.75 would remain the inefficiency, unless there are major changes in inputs and outputs. According to the efficiency acquired from DEA and the information of variables, the classification is shown in Table 1. One DMU, about 8% of all DMUs, presents strong efficiency on agricultural products logistics, with the efficiency=1, revealing the better agricultural products logistics efficiency. Five DMUs, about 38% of all DMUs, show the agricultural products logistics efficiency in 0.9-1, as marginal inefficiency, revealing that such cities could easily promote the agricultural products logistics efficiency. Seven DMUs, about 54% of all DMUs, appear the agricultural products logistics efficiency lower than 0.9, as obvious inefficiency, where Lianyungang reveals the lowest agricultural products logistics efficiency 0.73.

## 6. Suggestion

According to the research analysis results in this study, suggestions for agricultural product logistics are proposed as followings.

i. Due to raising consumer awareness, consumers often question about the grading and packaging of agricultural products. The agricultural product packaging is designed with quality to reduce carrying, loading/unloading time, and storage space in order to enhance the transportation efficiency. Besides, more secure and tight packaging is designed for stacking

agricultural products to reduce transportation fee and costs.

ii. Direct selling is encouraged for agricultural products to accelerate the logistics efficiency and allow agricultural products being delivered to consumers freshly and promptly. Direct selling of agricultural products is essential for reinforcing the logistics efficiency, reducing the layers in the sales process, reinforcing the justice and general reports of prices on market, and expanding channels for win-win between farmers and consumers.

iii. Establishing a responsible brand to a brand with rapid and convenient distribution and further creating a brand to segment the market could have the agricultural products achieve the value-added effect and add value on the brand so that consumers are better satisfied with the demands for safe and healthy vegetables and fruits. Meanwhile, a business with quality agricultural brand could be established by matching with the governmental policies on safe agriculture to create the virtuous cycle among enterprises, the government, and consumers with continuous innovation.

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