A study on agricultural production and cost of logistics operation based on Analytic Hierarchy Process

Reception of originals: 02/05/2020
Release for publication: 07/18/2020

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Abstract

The expansion of agricultural logistics systems to develop the maximal effectiveness of transportation, supply, and marketing of agricultural products, complete the integration and diversity of supply and marketing of agricultural products, and enhance the added value of agricultural products is an extremely important issue and task. Aiming at farmers in Suzhou City, total 500 copies of questionnaire are distributed in this study, and 373 valid copies are retrieved, with the retrieval rate 75%. Effects of cost of production, cost of farm, and cost of logistics on agricultural revenue are analyzed with Jiangsu Province as the sample. The public data in China administrative division statistical yearbook are used for selecting indicators. The research results conclude the followings. 1. From the overall weight of evaluation indicators of agricultural production and cost of logistics operation, top five indicators, among 20 evaluation indicators, contain price of agricultural products, main crop revenue, farm facility, agricultural output, and labor cost. 2. Agricultural production and cost of logistics operation would positively affect agricultural revenue. According to the results, suggestions are proposed, expecting to help domestic agricultural products, under the mutual completion and comparison, for the difference in the cost of production and more efficient goods collection and delivery management.

Keywords: Agricultural production. Agricultural logistics. Cost of operation. Critical factor.

1. Introduction

Agriculture is the foundation of a country which would be safe with the firmed foundation. The agricultural strategic location is also considerable. People rely on food for survival. To develop agriculture under the situation of food being the necessity of people, the expansion of agricultural markets and the assistance in the development of agricultural industry are extremely important issues and tasks. Technological agricultural cultivation to further integrate the advantages of facilities agriculture and science and technology agriculture, grow high unit-price crops, and enhance yield per unit and members' income are the characteristics to establish agricultural cooperatives. Nowadays, with customer orientation, the unique management idea is emphasized by consumers. The effect of commercialization

results in population concentrating in cities to gradually marginalize and regionalize agricultural production as well as enlarge the distance of agricultural production and marketing. An agricultural production and marketing system consists of various complicated and multilayer parts. Agricultural products create profits for middle sellers, but form distinct problems. The threat of importing agricultural products to domestic agricultural products results in price competition and lucrative profits and further affects the price and marketing of domestic products. Importers, in order to make exorbitant profits, even exploit local labors to relatively cause the burden of domestic agricultural products.

The government encourages the export of agricultural products to achieve certain quality standards. Nevertheless, domestic agricultural production and sales channels are comparatively conservative that, in addition to high-standard agricultural science and technology basis, high-standard information electronics industry, and modern logistics channels, it is necessary to have efficient organizations promote the establishment of new systems and replace marketing models behind the times with knowledge innovation capability. Agricultural strategic alliance and agricultural logistics centers therefore are largely established. Supply chain logistics orientation is also the idea emphasized by agricultural cooperation organizations. In general, local collecting sites would concentrate goods and directly deliver to the place of consumption; few farmers would entrust outsourcing logistics industry with the transportation. In consideration of costs and expenses for agricultural products, it is more economical to have the collecting site concentrating goods for delivery. Agricultural products stress on freshness and rapidness, as agricultural products are perishable and hard to store. The point of supply chain logistics therefore stresses on rapidness. Concentrating regional agricultural resources to expand the agricultural logistics system could develop the maximal effectiveness of transportation, supply, and marketing of agricultural products, complete the integration and diversity of the supply and marketing of agricultural products, and promote the added value of agricultural products. In this case, agricultural production and cost of logistics operation are discussed in this study, expecting to assist domestic agricultural products, under mutual competition and comparison, in the difference in cost of production and more efficient goods collection and delivery management.

2. Literature Review

2.1. Agricultural production

Wang et al. (2017) stated that agricultural production was deeply affected by natural

environment as well as humanities and culture to present regional and diverse development trends. However, under the constant improvement of technological production and transportation, the restraint of natural environment to agricultural development was reducing. Al-Mansour & Jejcic (2017) mentioned that regional agriculture encountered the problems of rural emigration, human resource shortage caused by aging, and land price rise that farmers could merely make a living. Kumar & Mukherji (2018) indicated that farmers engaging in agricultural production had to enhance the yield and appearance & quality of agricultural products to match market demands and pursue high-value agricultural products. The use of pesticide and synthetic fertilizers were therefore enhanced in the cultivation process. Ventura et al. (2019) mentioned that organic farming was worth promotion as it could reduce costs and expenses of production and prevent exploitation in the transportation and sales process. Current organic vegetable and fruit farms still encountered dilemmas on the management; however, such dilemmas could be solved by farmers giving up egotism and expanding the business with existing competitive advantages to cooperate with other industries through strategic alliances. Chiarello & Moura (2018) argued that most past research studied the production and planning of regional agriculture with certainty and single goal model, but ignored that "agricultural production environment" was full of uncertainty and fuzziness. For this reason, the decision of planning and acquiring optimal agricultural production in an area, from the viewpoint of fuzzy environment, should be discussed. Matthee & Santana-Gallego (2017) studied the difficulties which farmers encountered in the cultivation, including "typhoon disasters", "threats from imported agricultural products", "inadequate or expensive fertilizers", "low sales prices", "cultivation labor shortage", and "lack of water". Among such problems, "typhoon disasters" and "lack of water" were natural environment factors, while other problems could be solved through agricultural administration organizations or regional farmers' organizations to enhance farmers' cultivation willingness.

2.2. Logistics operation

Yano & Cossu (2019) defined that logistics contained materials and service in sales as well as various activities in the process from place of production to place of consumption. Hawkins et al. (2019) defined logistics as the process to transfer material data from supply ends to demand ends with the least total costs and according to customer requirements. It mainly covered transportation, storage, packing, loading/unloading, delivery, distribution processing, and information processing. Bianchi (2017) regarded logistics as the physical

distribution of objects. In the distribution process, logistics functional activities of transportation, warehousing, loading/unloading, packing, distribution processing, and information were effectively combined through the management process to create value and satisfy customer and social needs. Simply speaking, logistics was the entire distribution process of articles from place of production to consumers or place of use. McFadden & Huffman (2017) divided logistics operation into delivery, manufacturing, and purchase. The combination of them comprehensively managed the transportation of materials and semi-finished products among specific locations and places, suppliers, and customers, and enterprises added value of the logistics process through the move of stock. Op de Beeck et al. (2017) mentioned that, in a typical supply chain system, products, after acquiring the materials, were manufactured through one or more factories, delivered to warehouses for storage, and then delivered to retailers or consumers. To reduce costs and improve service standards, effective supply chain strategies therefore should consider the mutual effects among distinct hierarchies in a supply chain, which was also called a logistics network. Fess & Benedito (2018) mentioned the critical issues in logistics operation. 1. Strategy level: referring to the long-standing and persistent effect of management idea. 2. Distribution network configuration: the transportation system from place of production to place of consumption. 3. Stock control: stock regulation required for coping with uncertain demands. 4. Supply contract: the basis of stable needs and income. 5. Distribution strategy: policies for transfer points and direct sales. 6. Supply chain integration and strategic partners: the development of partnership and cooperation model. 7. Outsourcing and purchase strategies: the import of agricultural products and the transaction method. 8. Product design: including packaging, marketing, and transportation. 9. Information technology and decision support system: advanced computer operation control and product supplying decisions and efficiency. 10. Customer value: pricing strategy and customer service, customer orientation.

2.3. Cost of agricultural product operation

Wang et al. (2018) pointed out two types of attrition in the vegetable marketing logistics. One was the removal of uneatable parts and surface leaves of vegetable, and the other was natural weight loss or the external factors of transportation and carrying. The former is currently regarded as the factor in high attrition rate, as farmers are used to keep 2-3 pieces of outer leaves when harvesting leaf vegetables, e.g. cabbage and celery cabbage, for protection and do not seal for wholesalers clearly seeing the goods. Such uneatable leaves,

after being transported to the place of consumption, are peeled by dealers or retailers for selling to consumers. As a matter of fact, such attrition is caused by unclear grading or not thoroughly organizing. However, it cannot be denied that farmers would cherish vegetables to appear different points of view from wholesalers. Carvalho (2017) mentioned that refrigerators for vegetable were not advanced so that the distribution of vegetable under sultry environment in summer would naturally enhance the attrition rate. Packaging is to wrap products with containers or solid plastics to become a unit of measurement. Packaging reveals convenient carrying and transaction and could reduce product attrition in the carrying and storage process. The creation of patterns with fashion could induce impulse buying and increase sales volume, maintain national health, and enhance the quality of life. Small packaging is handy and allows sellers reducing service time for individual customers to enhance sales efficiency, facilitate marketing effect, present the functions of advertisement and communication, be easy to preserve, and allow articles being stored for long time.

Liu et al. (2018) mentioned that agricultural products, after specialization, were mostly produced in advantageous areas to enlarge the distance with consumer markets. It therefore had to deliver products to the place of consumption through "transportation" to satisfy consumer needs. Mishra et al. (2018) indicated that the advance of highway systems and large mobility of large vehicles allowed directly delivering products to destinations; besides, the load weight of large vehicles was increased, such as the utilization of trucks and container trailers. Gomiero (2018) proposed that the expansion of production allowed adjacent farmers directly supplying products to the collecting site to solve the problem of inconvenient transportation as well as benefit producers in adjacent villages. Especially, time saving and expanding sales coverage could enhance the value of agricultural products to achieve the goal of "smooth flow of goods". After the promotion of transportation effectiveness, farmers could rapidly and directly sell the agricultural products and were encouraged to expand the production size and enhance the yield and product quality.

According to above literatures, the following hypothesis that agricultural production and cost of logistics operation would positively affect agricultural revenue is therefore established in this study.

3. Research Design and Method

3.1. Research method

Experts' questionnaire survey is applied to this study. In consideration of the problems

of mean, decision attribute correlation, and inaccurate group decision in traditional Delphi Method, Fuzzy Delphi Method (FDM) is applied and Analytic Hierarchy Process (AHP) are used for data analyses in this study to definitely select critical factors in the sustainable development of green meeting.

(1) Fuzzy Delphi Method (DM): Murry et al. first integrated fuzzy theory into traditional Delphi Method to express the value of corresponding variables through different human semantic levels. Murry et al. proposed such fuzzy semantic variables for evaluation, aiming to solve the fuzziness problem in traditional Delphi Method, but did not proposed specific calculation. Successive researchers proposed solutions, such as range, fuzzy integral, triangular fuzzy number, and dual-triangular fuzzy number.

(2) Analytic Hierarchy Process: After integrating expert opinions, the complicated decision-making system is constructed as a hierarchical system which is expanded by hierarchies for clarifying problems. Various dual evaluations are then completed according to paired comparison to evaluate the importance of relative factor weights.

3.2. Establishment of evaluation indicators

The questionnaire in this study is emailed to experts in different fields. The first-time feedback from experts is organized to calculate the considered factors for agricultural production and cost of logistics operation. Such factors with similar properties are classified into a category and mailed back to the experts for the opinions. With several runs of inquiries, the major classifications are achieved. An expert meeting is held by calling all experts to set the critical factors in agricultural production and cost of logistics operation, including cost of production, cost of farm, agricultural revenue, and cost of logistics. Such critical factors are regarded as the AHP dimensions, and the AHP questionnaire is established based on the corresponding categories. The followings are the research guidelines after the revision with Delphi Method.

(1) Cost of production: sprout expense, fertilizer expense, labor cost, labor cost, material cost, energy cost, farm facility, and agricultural machinery and implement cost.

(2) Cost of farm: land rent, land value, planted area, and land location.

(3) Agricultural revenue: main crop revenue, by-product revenue, price of agricultural products, and agricultural output.

(4) Cost of logistics: packing fee, transportation fee, management and marketing cost, and storage charge.

3.3. Research object

Aiming at farmers in Jiangsu Province, total 500 copies of questionnaire are distributed in this study, and 373 valid copies are retrieved, with the retrieval rate 75%. The effects of cost of production, cost of farm, and cost of logistics on agricultural revenue are analyzed with Suzhou City as the sample. The public data of administrative division statistical yearbook are used for selecting the indicators for data analyses in order to provide reference for improvement.

4. Data Analysis Result

4.1. Data Integration

After completing all hierarchical weights, it is distributed according to the relative importance of indicators in various hierarchies to show the importance of indicators in the entire evaluation system as well as to generate the overall weight of factors in agricultural production and cost of logistics operation, Table 1.

Table 1: Overall weight of factors in agricultural production and cost of logistics operation

dimension	indicator	overall weight	overall sequence
cost of production	sprout expense	0.028	15
	fertilizer expense	0.063	6
	labor cost	0.075	5
	labor cost	0.020	18
	material cost	0.051	9
	energy cost	0.017	19
	farm facility	0.089	3
	agricultural machinery and implement cost	0.057	8
cost of farm	land rent	0.011	20
	land value	0.043	11
	planted area	0.040	12
	land location	0.023	17
agricultural revenue	main crop revenue	0.097	2
	by-product revenue	0.035	13
	price of agricultural products	0.107	1
	agricultural output	0.080	4
cost of logistics	packing fee	0.046	10

	transportation fee	0.060	7
	management and marketing cost	0.026	16
	storage charge	0.032	14

4.2. Effects of cost of production, cost of farm, and cost of logistics on agricultural revenue

By selecting the critical factors in agricultural production and cost of logistics operation, more important evaluation indicators are selected as the factors for regression analyses to test the hypothesis and theoretical structure. The first regression, Table 2, reveals the significance of the regression equation ($F=66.738$, $p<0.001$). Agricultural production and cost of logistics operation show remarkable effects on main crop revenue, where "farm facility", "labor cost", "fertilizer expense", "transportation fee", "agricultural machinery and implement cost", "material cost", and "packing fee" in agricultural production and cost of logistics operation appear notably positive effects on main crop revenue. The second regression, Table 2, presents the significance of the regression equation ($F=47.556$, $p<0.001$). Agricultural production and cost of logistics operation reveal significant effects on by-product revenue, where "farm facility", "labor cost", "fertilizer expense", "transportation fee", "agricultural machinery and implement cost", "material cost", and "packing fee" in agricultural production and cost of logistics operation show remarkably positive effects on by-product revenue. The third regression, Table 2, appears the significance of the regression equation ($F=83.815$, $p<0.001$). Agricultural production and cost of logistics operation present notable effects on price of agricultural products, where "farm facility", "labor cost", "fertilizer expense", "transportation fee", "agricultural machinery and implement cost", "material cost", and "packing fee" in agricultural production and cost of logistics operation reveal significantly price of positive effects on agricultural products. The fourth regression, Table 2, shows the significance of the regression equation ($F=52.174$, $p<0.001$). Agricultural production and cost of logistics operation show remarkable effects on agricultural output, where "farm facility", "labor cost", "fertilizer expense", "transportation fee", "agricultural machinery and implement cost", "material cost", and "packing fee" in agricultural production and cost of logistics operation appear notably positive effects on agricultural output. Accordingly, the hypothesis that agricultural production and cost of logistics operation would positively affect agricultural revenue is supported.

Table 2: Regression analysis of critical factor to agricultural revenue

dependent variable→	agricultural revenue							
independent variable↓	main crop revenue		by-product revenue		price of agricultural products		agricultural output	
	β	ρ	β	ρ	β	ρ	β	ρ
farm facility	2.837**	0.000	1.762*	0.021	2.438**	0.000	2.527**	0.000
labor cost	2.751**	0.000	2.517**	0.000	2.663**	0.000	2.587**	0.000
fertilizer expense	2.688**	0.000	2.236**	0.000	2.453**	0.000	2.344**	0.000
transportation fee	2.463**	0.000	2.093**	0.000	2.738**	0.000	1.809*	0.015
agricultural machinery and implement cost	2.386**	0.000	2.162**	0.000	2.267**	0.000	2.248**	0.000
material cost	2.241**	0.000	2.216**	0.000	2.184**	0.000	2.196**	0.000
packing fee	2.138**	0.000	2.327**	0.000	2.579**	0.000	1.697*	0.032
F	66.738		47.556		83.815		52.174	
P	0.000***		0.000***		0.000***		0.000***	
R2	0.488		0.385		0.681		0.432	
adjusted R2	0.449		0.353		0.653		0.407	

Note: * stands for $p<0.05$ and ** for $p<0.01$.

5. Conclusion

The empirical analysis results of this study present the following conclusions.

Among the evaluation indicators, the hierarchical weights of evaluation indicators are sequenced as below.

- In terms of cost of production, the evaluation indicators are sequenced farm facility, labor cost, fertilizer expense, agricultural machinery and implement cost, material cost, sprout expense, labor cost, and energy cost.
- Regarding cost of farm, evaluation indicators are sequenced land value, planted area, land location, and land rent.
- In regard to agricultural revenue, the evaluation indicators are sequenced price of agricultural products, main crop revenue, agricultural output, and by-product revenue.
- In terms of cost of logistics, the evaluation indicators are sequenced transportation fee, packing fee, storage charge, and management and marketing cost.

From the overall weight of evaluation indicators of critical factors in agricultural production and cost of logistics operation, top five indicators, among 20, are sequenced price of agricultural products, main crop revenue, farm facility, agricultural output, and labor cost.

Agricultural production costs are the primary burden for famers as well as the important indicator for production. Under farmers' general cognition, agricultural facility cost, labor cost, fertilizer expense, and material cost appear higher importance, i.e. more important burden for farmers, and are the factors to which farm managers should pay attention, such as maintenance of facilities, wages, use of fertilizers, and material saving. Stock management is a primary part in a logistics system; especially, it is not easy to balance both supply and marketing parties. Uneven supply and marketing of agricultural products is quite common due to unpredictable factors of climate, immediacy, and perishability. In this case, the expansion of product channels and the reduction of stock costs are the principles. Transportation is an important tool in logistics systems. Without large delivery tools, products would not be immediately delivered for sales. As a result, vegetable and fruit marketing cooperative society should purchase large transportation tools to cope with the uncertainty of customer needs.

6. Suggestion

According to the conclusions, the following suggestions are proposed in this study, expecting to provide definite guidance and directions for promoting the development of agricultural production.

- Wages for agricultural production workers show large ratio, while the overall wage standard is not worth mentioning. To increase wage standards, it is necessary to enhance prices of agricultural products and yield as well as reduce other costs. It is worth reference for relevant departments and agricultural managers.
- Due to the rise of consumer awareness, consumers often question the grading and packaging of agricultural products. To enhance transportation efficiency, agricultural product packaging should be designed with quality and saving carrying, loading/unloading time, and storing space. Agricultural products should be stacked with safer and tighter packing to save transportation fee and cost. In this case, agricultural product packing should classify the product quality, packing materials, and storage places for the most economical space benefit.
- Farmers' organizations have been guided by government institutions to result in farmers' dependency, but not seeing the positive measures to technological and modernized

management. For this reason, it should start from the reform of production and channels to enhance the quality and price of agricultural products. It would be the national fortune and the happiness of citizens.

- It is necessary to encourage direct marketing of agricultural products to accelerate the agricultural logistics efficiency so that agricultural products could be freshly and immediately delivered to consumers. Direct marketing of agricultural products could cope with the problems of rising vegetable prices and exploitation of intermediate traders, reinforce the effectiveness of agricultural logistics, and reduce the links in the sales of agricultural products. To strengthen the fairness and universality of agricultural product reports and to expand the agricultural product channels are the ways to create win-win between farmers and consumers.

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8. **Acknowledgments**

This work is supported by the Guangxi Zhuang Autonomous Region: 100 Plan on the Introduction of High-level Overseas Talents for Colleges and Universities in Guangxi.