

# Analysis and Optimization of Supply Chain Operation Performance of Characteristic Agricultural Products in County Region under Rural Revitalization Strategy

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## ABSTRACT

Under the background of China's rural revitalization strategy, it is of great significance to analyze and optimize the supply chain operation of characteristic agricultural products in the county region to help agricultural products "go out of the village and enter the city". According to the characteristics of county development, the SCOR model is improved, and the analysis framework of supply chain operation performance of characteristic agricultural products is constructed. Taking the characteristic agricultural products in LJ City, Zhanjiang as an example, the supply chain operation research and data collection are carried out, and the Cloud Model is used to evaluate and analyze the operation performance. It is found that there are some key problems in it, such as poor information sharing, low processing degree of agricultural products, poor matching between planning and demand, and high loss rate of product distribution. Some optimization suggestions are put forward, such as building an industrial information sharing platform, developing agricultural products processing industry, establishing small-scale associations for proprietary agricultural products and speeding up the construction of cold chain logistics, in order to provide reference for the optimization of supply chain operation of characteristic agricultural products and help the realization of rural revitalization strategy.

## KEYWORDS

Characteristic agricultural products; County region; Supply chain performance; Cloud Model; Rural revitalization strategy.

## 1. INTRODUCTION

With the implementation of China's rural revitalization strategy, the dividends of agricultural industrialization development have been further unleashed. Agricultural products, as the core of agricultural industrialization development, have been provided with new opportunities for development by the rural revitalization strategy. Characteristic agricultural products, as superior commodities in county agricultural products, have become the most important "golden key" for farmers to get rich in the process of rural revitalization (Xiao et al., 2023). Meanwhile, in recent years, digital, information, Internet and other technologies have spawned new retail. New retail profoundly changes people's consumption habits and affects the whole process of enterprise product production, circulation and distribution (Hu P., 2021). It helps agricultural enterprises and farmers in the county to sell agricultural products to other far place, increases their income, and also helps them buy back the agricultural materials they need to help the high-quality development of agricultural products. Under the influence of new retail, consumers have higher and higher requirements for agricultural

products and services. In addition to taste and manufacturing technology of the fresh product, they also pay attention to its freshness, quality and safety, efficient transportation and quick handling of returns.

To cope with the changes brought about by new retail, meet consumer demands, and help characteristic agricultural products gain market share, it is urgent to improve and optimize the supply chain of characteristic agricultural products in county-level areas (Zhen et al., 2022). Indeed, understanding the operational performance of the supply chain for characteristic agricultural products is crucial to analyze and solve existing problems, thereby optimizing its operations. Therefore, in the context of rural revitalization strategy, it is necessary and meaningful to evaluate the operational performance of the supply chain for characteristic agricultural products in county-level areas, analyze key issues, and propose targeted optimization suggestions.

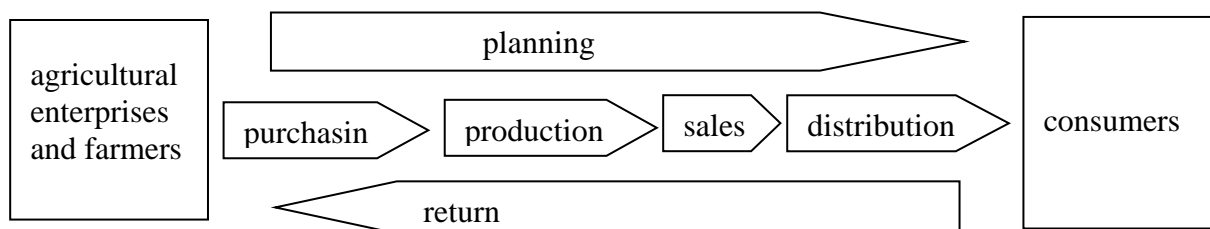
At present, the research related to the operation of agricultural product supply chain mainly focuses on the mode discussion. For example, Gao et al. (2017), Li et al. (2017) and Wang et al. (2018) respectively analyzed the advantages and disadvantages of the existing agricultural product supply chain operation mode from the perspectives of the development status of agricultural product logistics in China, the background of the Silk Road Economic Belt and farmers' professional cooperatives, pointed out the existing problems, and put forward mode selection or corresponding optimization suggestions. Liu Y. (2020) and Mei B. (2021) respectively use big data or information services and intelligent platforms to optimize the operation mode of fresh agricultural products supply chain. Wang et al. (2021) and Zhao et al. (2022) constructed and discussed the operation mode of fresh agricultural products supply chain in view of the phenomenon of live broadcast e-commerce community. Wang Z. (2016) put forward three closed supply chain management modes of green agricultural products with leading agricultural enterprises, green agricultural products logistics centers and supermarkets as the core enterprises. The study of these operation modes has certain reference significance for optimizing the operation of characteristic agricultural products supply chain, but it is difficult to judge its current situation and find existing problems because it does not involve the specific evaluation of operation performance. Therefore, some other scholars focus on the research of the operational performance of agricultural products supply chain. For example, Su et al. (2019) and Abula et al. (2022) used DEA method to evaluate the operational efficiency of Nanping agricultural products supply chain and cross-border agricultural products supply chain in Central Asia. He et al. (2020) used the fuzzy Kano model to construct the performance analysis model of fresh agricultural products supply chain. Ableeva et al. (2019) designed the evaluation index system of management efficiency of agricultural products supply chain, and conducted empirical performance evaluation. Ding et al. (2023) established a performance evaluation index system for agricultural products supply chain under the background of agricultural commerce interconnection from four aspects: production, business process, logistics, and consumers, and constructed a PCA-DEA-TOPSIS three-stage integrated evaluation model. Although the above research has constructed the evaluation system and method of agricultural products supply chain operation performance, it has not considered the characteristics of agricultural product supply chain under the new retail and still lacks the design of evaluation index system from the perspective of the whole vertical process of supply chain.

Therefore, under the background of rural revitalization strategy, this paper considers the characteristics of agricultural enterprises and farmers in the current county-level characteristic agricultural product supply chain, and constructs an analysis framework of supply chain operation performance based on improved SCOR model from the perspective of the whole vertical process of supply chain. Taking LJ city in Zhanjiang as an example, this paper investigates and collects the supply chain data of characteristic agricultural products, and makes an empirical performance evaluation by using Cloud Model method, so as to analyze the existing key problems and give relevant targeted suggestions. It is expected to provide guidance and reference for county agricultural

enterprises and farmers in the evaluation and optimization of supply chain operation under the rural revitalization strategy.

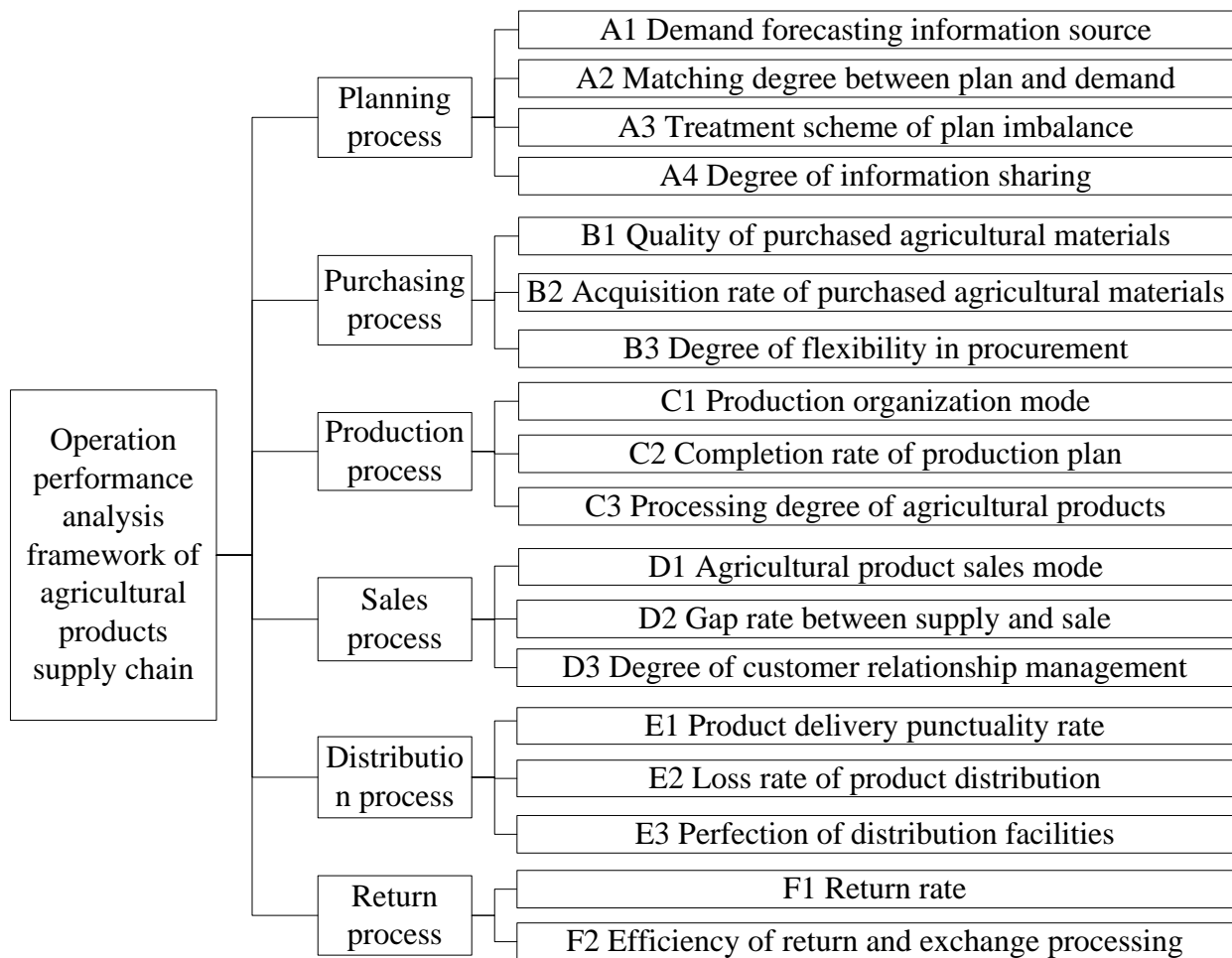
## 2. DESIGN OF OPERATIONAL PERFORMANCE ANALYSIS FRAMEWORK

SCOR model is a supply chain diagnostic tool, and its top-level content includes five processes: planning, purchasing, production, distribution and return. Its evaluation can measure the performance of supply chain, reflect its performance characteristics and gain insight into the problems existing in each process. In SCOR model, sales is not regarded as a process independently, but is weakened into order management in distribution process. This may be related to the traditional supply chain management focusing on the manufacturing-centered physical docking process between supply and demand. With the rise of new retail and the popularization of e-commerce in rural areas in recent years, an increasing number of agricultural enterprises and households in counties have started to join the retail industry. They are utilizing the internet, e-commerce, and media platforms to directly sell their agricultural products, making the sales and manufacturing of agricultural products increasingly inseparable. As a result, the role of sales in the agricultural product supply chain is becoming increasingly important. Therefore, it is necessary to analyze sales as a separate process in the SCOR model. This paper takes into account the fact that agricultural enterprises and households in rural areas currently have the ability to conduct online sales and are actively participating in it. The improved model in the SCOR framework includes six major processes: planning, purchasing, production, sales, distribution and return. Refer to Figure 1 for details.



**Figure 1.** The Top Six Processes of the Improved SCOR Model

According to Figure 1 and referring to the application practice of scholars such as Ayyildiz et al. (2020), Lima-Junior et al. (2021) in designing the evaluation system by using SCOR model, from the perspective of a comprehensive supply chain system, this paper takes the top six processes of the improved SCOR model as six analysis categories, and then selects relevant design indicators in each category, and determines 18 specific indicators to form a complete analysis framework (as shown in Figure 2).



**Figure 2.** Operation Performance Analysis Framework of Agricultural Products Supply Chain

### 3. ANALYSIS OF SUPPLY CHAIN OPERATION PERFORMANCE OF CHARACTERISTIC AGRICULTURAL PRODUCTS IN COUNTY REGION BASED ON CLOUD MODEL

On the basis of the operational performance analysis framework in Figure 2, taking LJ city in Zhanjiang, Guangdong Province as an example, the county-level city is investigated to obtain data, and the Cloud Model is used for evaluation and analysis to reveal the operational performance status and key issues of its agricultural products supply chain.

#### 3.1. Data source

Taking LJ City of Zhanjiang City as the research scope, according to the information data of "National Famous and Excellent New Agricultural Products Directory Collection and Login Information System" and the mention rate of Baidu intelligent search results, Red Orange and Feizixiao Litchi are determined as the research objects. The index content of the analysis framework in Figure 2 is designed as corresponding questionnaires. A total of 500 questionnaires are distributed to agricultural enterprises and farmers related to two kinds of characteristic agricultural products, and 449 questionnaires are actually received. After excluding the invalid questionnaires, 434 questionnaires can be analyzed, and the questionnaire efficiency is 96.7%, as shown in Table 1.

For the answer options of each question in the questionnaire, according to the order of the description of the options from poor to excellent, increase 0.2 step by step from 0 to give scores, that is, 0, 0.2, 0.4, 0.6, etc. For the answer options of reverse indicators "Gap rate between supply and sale", "Loss

rate of product distribution” and “Return rate”, reverse scores are given. After scoring, in order to facilitate the analysis and comparison of data and eliminate the influence caused by different score ranges of different questions, the original scoring values of all question options are standardized. It map the values in the interval of  $[0,1]$  and the specific deviation standardization formula is  $x' = x/(max - 0)$ .  $x'$  is the assigned value after the option is standardized.  $x$  is the original assigned value of the option.  $max$  is the maximum original score of this question option. From this, the standard score of each question option in the questionnaire can be obtained. The 434 valid answers are processed and counted in the above way, and the processed complete data set can be obtained.

**Table 1.** Questionnaire Situation

County Region	Characteristic products	Number of distribution	Recycled number	Effective recovery number	Effective recovery rate %
LJ city	Red Orange	250	248	240	96.8
	Feizixiao Litchi	250	201	194	96.5
	Total	500	449	434	96.7

### 3.2. Define Cloud Model

Cloud Model is an uncertainty transformation model between a qualitative concept expressed by linguistic values and its quantitative representation. It mainly reflects the fuzziness and randomness of concepts in the objective world or human knowledge. Cloud Model has three digital characteristics: Expected value (Ex), Entropy (En) and super-entropy (He). Ex is the expectation of the spatial distribution of cloud droplets in the universe, represents the point value of qualitative concept, and reflects the cloud center of cloud droplet group of this concept. En is the degree of uncertainty, which is determined by the degree of dispersion and the degree of fuzziness, and represents the uncertainty and fuzziness of cloud droplet distribution. He is an uncertainty measure of En, which reflects the uncertainty of the model and the thickness of the cloud. The greater He is, the greater the uncertainty of the model and the thickness of the cloud.

The algorithm steps of the forward cloud generator are as follows:

A. Generate a normal random number  $\overline{En}$  with En as expectation and  $He^2$  as variance.

B. Generate a normal random number  $x$  with Ex as expectation and  $En^2$  as variance.

C. Calculate the membership degree by the formula  $y = \exp\left(-\frac{(x - Ex)^2}{2\overline{En}^2}\right)$ .

D. Combine  $(x, y)$  to form a cloud drop.

E. Repeat steps 1~4 until the set number N cloud drops are generated.

### 3.3. Digital characteristics and atlas analysis of Cloud Model

According to the data set obtained in section 3.1 and the principle of Cloud Model algorithm in section 3.2, assuming that the number of cloud drops is  $N=3000$ , the three digital characteristics of the framework indicators of supply chain operation performance analysis can be obtained by using MATLAB software programming for Cloud Model, as shown in Table 2.

From the digital characteristics of indicators in Table 2, we can see that the expectations of some indicators are low, such as Degree of information sharing, Treatment scheme of plan imbalance, and Loss rate of product distribution. In order to clarify the main problems existing in the operation

performance of the supply chain of characteristic agricultural products in LJ City, the digital characteristic results of Cloud Model evaluation are compared and sorted, and it can be concluded that the expected value of evaluation is  $A4 < C3 < A2 < A3 < C2 < B3 < D3 < E2 < A1 < E3 < C1 < D1 < B1 < E1 < D2 < B2 < F1 < F2$ . This shows that compared with the latter indicators such as B1, E1 and B2, the evaluation of the former indicators such as A4, C3, A2 and A3 are currently in a less satisfactory state, which are the key factors that cause the poor operation performance of agricultural products supply chain.

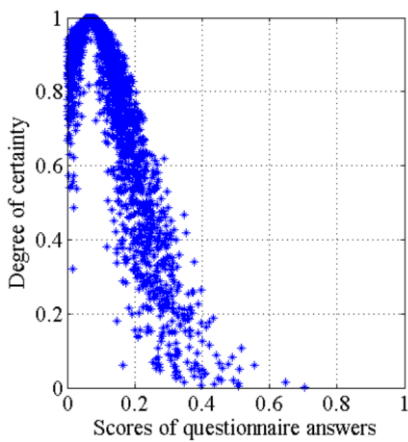
Therefore, the top eight key indicators are selected, and their cloud atlas are drawn by using MATLAB software (see Figure 3~ Figure 10). The performances of these cloud atlas are analyzed in detail, and the possible reasons for the index problems are analyzed.

**Table 2.** The Three Digital Characteristics of the Framework Indicators

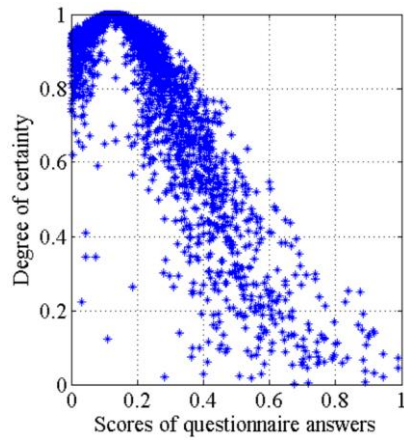
No.	Indicator	Cloud data(Ex, En, He)
1	A1 Demand forecasting information source	(0.4211, 0.1641, 0.0563)
2	A2 Matching degree between plan and demand	(0.1740, 0.2944, 0.1352)
3	A3 Treatment scheme of plan imbalance	(0.2039, 0.1979, 0.0379)
4	A4 Degree of information sharing	(0.0693, 0.1228, 0.0348)
5	B1 Quality of purchased agricultural materials	(0.6244, 0.2137, 0.0831)
6	B2 Acquisition rate of purchased agricultural materials	(0.7210, 0.1389, 0.0128)
7	B3 Degree of flexibility in procurement	(0.2863, 0.1985, 0.0985)
8	C1 Production organization mode	(0.4611, 0.2445, 0.0521)
9	C2 Completion rate of production plan	(0.2765, 0.3274, 0.1804)
10	C3 Processing degree of agricultural products	(0.1267, 0.2503, 0.0744)
11	D1 Agricultural product sales mode	(0.5590, 0.3511, 0.1800)
12	D2 Gap rate between supply and sale	(0.6678, 0.0980, 0.0732)
13	D3 Degree of customer relationship management	(0.3096, 0.1430, 0.0698)
14	E1 Product delivery punctuality rate	(0.6633, 0.1439, 0.0402)
15	E2 Loss rate of product distribution	(0.4192, 0.1233, 0.0588)
16	E3 Perfection of distribution facilities	(0.4476, 0.1569, 0.0324)
17	F1 Return rate	(0.7212, 0.1705, 0.0644)
18	F2 Efficiency of return and exchange processing	(0.7986, 0.1137, 0.0937)

According to Figure 3~ Figure 5, the Ex values of degree of information sharing, processing degree of agricultural products and matching degree between plan and demand are all lower than 0.2, which are the most important problem of supply chain operation performance. As we can be seen from Figure 3, the Ex value of degree of information sharing is basically close to 0 in the universe [0,1], indicating that the evaluation expectation is very low; In addition, the horizontal axis interval mainly distributed in 0~0.5, which shows that the discrete ambiguity is low, the cohesion is high, and the entropy En value is not large; At the same time, the clouds are concentrated and highly condensed, that is, the super-entropy He value is small. The above shows that the degree of information sharing is very low, and this phenomenon is extremely common among the respondents, which is a common

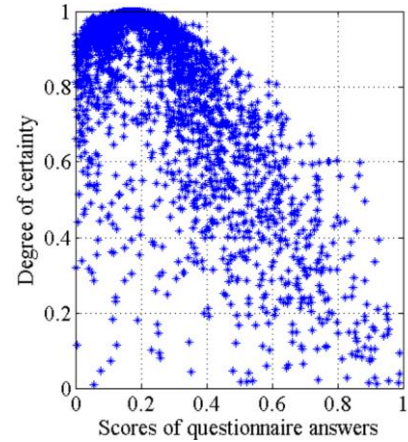
serious problem. The cause of the problem may be related to the poor awareness of information sharing, low technology and limited channels of agricultural enterprises and farmers in the county.



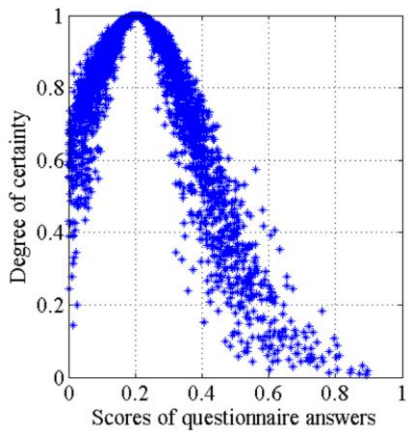
**Figure 3.** Cloud Atlas of A4



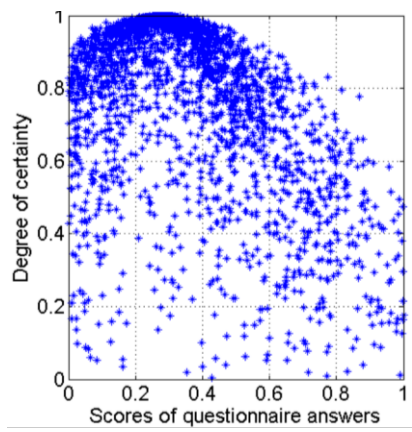
**Figure 4.** Cloud Atlas of C3



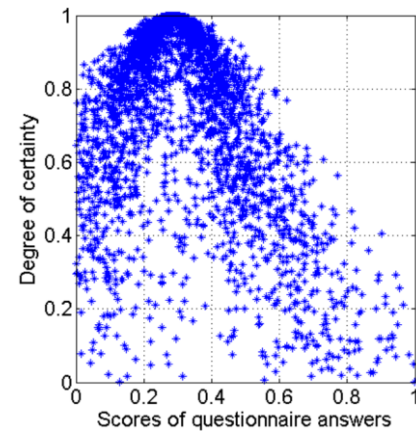
**Figure 5.** Cloud Atlas of A2



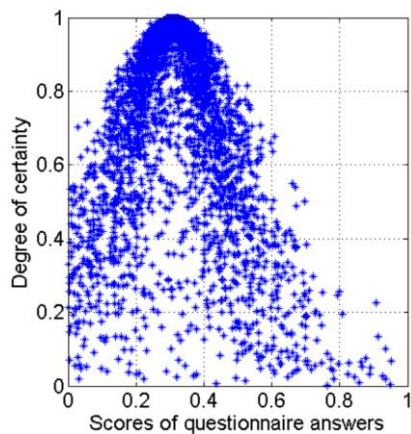
**Figure 6.** Cloud Atlas of A3



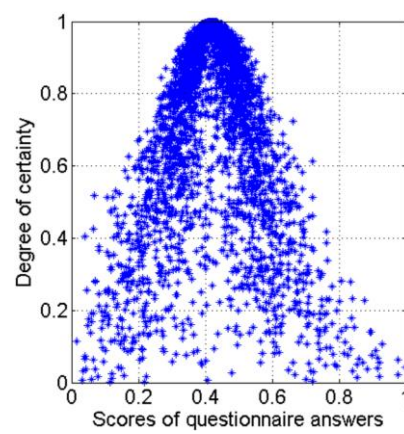
**Figure 7.** Cloud Atlas of C2



**Figure 8.** Cloud Atlas of B3



**Figure 9.** Cloud Atlas of D3



**Figure 10.** Cloud Atlas of E2

As we can be seen from Figure 4 and Figure 5, the Ex values of processing degree of agricultural products and matching degree between plan and demand are also low, but relative to degree of information sharing, the cloud droplet cohesion degrees of them are slightly lower from the horizontal axis of cloud coverage and the thickness of cloud droplets, which indicate that the two phenomena are also common but not extreme. At the same time, on the whole, the Ex value of matching degree between plan and demand is higher than that of processing degree of agricultural products, but the condensation saturation of the former is lower than that of the latter. From the finding we can know

that processing degree of agricultural products and matching degree between plan and demand are more serious in the current operation of agricultural products supply chain in county region, but a few enterprises have performed well in these two aspects, especially in matching degree between plan and demand. For the problem of processing degree of agricultural products, the causes of the problem may be related to the unformed processing industry, unclear sales channels of processed products and insufficient processing technology, while the mismatch between plan and demand may be related to insufficient acquisition of demand information, unscientific planning and lack of awareness and coordination mechanism of plan management and control.

From Figure 6 to Figure 8, it can be seen that the Ex values of treatment scheme of plan imbalance, completion rate of production plan and degree of flexibility in procurement are all between 0.2 and 0.3, which shows that the evaluation of the three is still low and should be paid attention to. The causes of the problem of treatment scheme of plan imbalance may be related to the decentralized structure of the supply chain, low degree of cooperation and weak sense of cooperation concept. From Figures 7 and 8, it is found that the cloud drops of completion rate of production plan and degree of flexibility in procurement are scattered and random, and the cohesion degree are low, especially degree of flexibility in procurement, which shows that although the overall evaluation values are low in these two aspects, some agricultural enterprises and farmers perform well. The reasons for the low completion rate of production plan may be related to the great influence of natural crops on the environment, the lack of agricultural production technology and improper production control. The reasons for the low degree of flexibility in procurement may be related to the low cooperation and coordination of supply chain, imperfect supplier management mechanism and lack of channel resources.

According to Figure 9 and Figure 10, it can be seen that the Ex values of degree of customer relationship management and loss rate of product distribution are between 0.3 and 0.5, and the cloud drops are concentrated and random, belonging to the type of high cohesion, which shows that the performance of agricultural enterprises and farmers in these two aspects is relatively consistent, so these two problems belong to a more common phenomenon. Low degree of customer relationship management may be related to small farmers' poor service consciousness, lack of information management system and imperfect service mechanism, while high loss rate of product distribution may be related to poor protection of distribution packaging, low cold chain rate and improper loading and unloading operation.

Based on the above analysis, it can be found that degree of information sharing, Processing degree of agricultural products, matching degree between plan and demand and treatment scheme of plan imbalance are the key problems that cause the low operation performance of supply chain in turn, while the problems with high universality are mainly concentrated on the index problems with high cloud drop cohesion and cohesion, namely, degree of information sharing, treatment scheme of plan imbalance, degree of customer relationship management and loss rate of product distribution.

In addition, except for the eight indicators shown in the cloud map, the Ex value of demand forecasting information source, perfection of distribution facilities and production organization mode in Table 2 are all lower than 0.5, which indicates that they are lower than the medium level, and they are also the stumbling blocks to improve the operation performance of the agricultural product supply chain in this county, which also need to be paid attention to and solved.

## **4. COUNTERMEASURES TO OPTIMIZE THE OPERATION PERFORMANCE OF CHARACTERISTIC AGRICULTURAL PRODUCTS SUPPLY CHAIN IN COUNTY REGION**

### **4.1. Build an industrial information sharing platform to help the supply chain cooperate closely**

A proprietary information sharing platform for characteristic agricultural products should be established, integrating industry related information and timely publishing it on the platform. A module should be constructed for free registration and internal interaction among members of the industry chain. The module functions should include real-time communication channel, information data upload channel, and data integration analysis, so as to achieve the integration of procurement, production, and sales information content in the supply chain. At the same time, supply chain partnership promotion activities should be carried out in various rural areas of the county to enhance the cooperation awareness of agricultural enterprises and farmers, thereby strengthening communication and information sharing among members of the supply chain.

### **4.2. Develop agricultural products processing industry and extend industrial chain**

Based on the characteristics of agricultural products in county region, it is necessary to further develop deep processing industry and build brands, extend the industrial chain, and improve the added value of characteristic agricultural products. For example, fresh red orange can be further processed and extended to orange juice, orange enzyme, orange wine, orange sugar and other products, while Feizixiao litchi can be extended to litchi soda, litchi yogurt, litchi fermented wine and other products. The deep processing of characteristic agricultural products can not only increase the added value of products, but also help solve the problems of regional sales and seasonal sales that were limited in the past. Therefore, the characteristics of agricultural products should be fully considered, and agricultural enterprises should be encouraged to carry out deep processing of agricultural products with conditions. At the same time, investment should be attracted, and enterprises should be orderly welcomed to settle in, forming a cluster of characteristic agricultural product industry chains.

### **4.3. Establish small-scale associations of proprietary agricultural products to improve the efficiency of mutual assistance and cooperation**

Based on the existing situation of characteristic agricultural products in county region, establish small-scale associations for segmented products to promote mutual assistance and cooperation between agricultural enterprises and farmers of the same characteristic agricultural products. Unlike the current agricultural cooperatives, which cover a wide range of products and have complex service functions, small-scale associations of proprietary agricultural products are only aimed at agricultural enterprises and farmers with the same characteristic agricultural products, and have strong service specializations, such as targeted promotion of demand forecasting and communication between agricultural enterprises and farmers with the same product, assistance in procurement cooperation, coordination and matching of agricultural enterprises and farmers when planning and production are imbalanced. By establishing small-scale associations of proprietary agricultural products, the actual cooperation and mutual assistance effect between counties and townships can be greatly improved.

### **4.4. Conduct service training lectures to enhance service awareness and level**

The current customer service concept and awareness in county region are poor. Regular training lectures should be held to enhance customer service, including the relationship between customer satisfaction, loyalty, and business operations, methods for improving service quality, and customer

relationship management. This is to convey good customer service concepts and methods to agricultural enterprises and farmers, and establish strong customer service awareness.

#### **4.5. Accelerate the construction of cold chain logistics and improve infrastructure**

Fresh agricultural products generally have the characteristics of high moisture content, easy decay, and spoilage. In addition, poor road conditions in counties and townships make it easier to cause significant loss of agricultural products during transportation. Accelerating the construction of cold chains and improving related infrastructure can effectively reduce the loss rate of agricultural products. On the one hand, cold chains can better maintain the freshness of agricultural products, and on the other hand, improving infrastructure such as highways can maintain good road conditions to prevent agricultural product damage. Therefore, it is imperative to continuously promote the cold chain logistics of characteristic agricultural products in county region, as well as improve infrastructure, which is a necessary path to help rural revitalization.

### **5. CONCLUSION**

In the context of rural revitalization strategy, this paper takes the operational performance of characteristic agricultural products supply chain in county region as the research object. It constructs a framework for analyzing and optimizing the operational performance of agricultural products supply chain. Taking the characteristic agricultural products in LJ City as an example, it uses Cloud Model to evaluate the operation status of the supply chain under the analysis framework. Furthermore, it analyzes the key issues currently existing and proposes targeted optimization recommendations.

From the case study, it can be seen that the current supply chain operation performance of Red Orange and Feizixiao Litchi is common. There are still some prominent key problems in them, such as low information sharing and cooperation among partners in the supply chain, short industrial chain of agricultural products, lack of deep processing, poor flexibility in procurement and supply-demand docking, and weak customer service awareness. These problems may be common problems in the operation of characteristic agricultural products supply chain in most counties and townships in China. Solving these key problems and improving the operation performance of agricultural products supply chain in county region are the only way to help the development of characteristic agricultural products industry, promote urban-rural integration and revitalize rural economy. Therefore, improving cooperation mechanism and agreement, promoting cooperation and alliance among members of characteristic agricultural products supply chain in county region, strengthening information sharing and exchange, and improving cold chain system and logistics infrastructure and equipment should be the contents that relevant enterprises and governments should pay attention to and start to promote.

### **ACKNOWLEDGEMENTS**

We graciously acknowledge the helpful comments of the Editor and the anonymous reviewers. This research is supported by The Philosophy and Social Science Planning Project of Zhanjiang, China (Grant No. ZJ23YB41), and The Project of Guangdong Coastal Economic Belt Development Research Center, China (Grant No. 20234L06).

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