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RESEARCH ON RISK MANAGEMENT OF FRESH AGRICULTURAL PRODUCTS SUPPLY CHAIN BASED ON FUZZY ANALYTIC HIERARCHY PROCESS

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ABSTRACT

There's a great improvement in people's requirements for food quality under the development of the economy, which leads to the nutrition and health of fresh agricultural products more and more loved by people. However, the characteristics of fresh produce itself, the inevitable high requirements for the surrounding environment and logistics level, and the unpredictable environment and relatively backward logistics development level inevitably increase the risks of the supply chain, the risk of fresh produce determines the need for research by practitioners and researchers concerned with fresh produce. This paper uses fuzzy analytic hierarchy process to analyze the risks in the fresh agricultural product supply chain, and summarizes the four models of China's fresh agricultural product supply chain enterprises, supermarket chains, wholesale markets, and fresh electronic business. There are six categories: production risk, demand risk, supply risk, cooperation risk, logistics risk, and environmental risk, thus establishing a risk evaluation indicator system. It is expected to put forward the risk management strategy to promote the supply chain development of fresh agricultural products.

Contribution/ Originality: The main contribution of this paper is to discover the four models of China's fresh agricultural products processing enterprise supply chain, chain supermarkets, wholesale markets, and fresh electronic business. The production risks, demand risks, supply risks, and risk factors of fresh agricultural product supply chain risk factors are summarized. Six risks of cooperation risk, logistics risk and environmental risk, and establish a risk evaluation index system.

1. INTRODUCTION

China is the world's largest producer of fresh agricultural products, with vegetables accounting for 52%, fruits 22%, meat 32% and aquatic products 31%. Every year, 4 trillion tons of vegetables enter the circulation. As an essential part of modern agriculture, fresh agricultural products' supply chain operation is related to the guarantee and improvement of people's livelihood (Lin and Tijun, 2015). The perishable and perishable characteristics of fresh agricultural products, as well as the increasingly fierce market competition, make enterprises pay more attention to the quality of fresh agricultural products, and put forward higher development requirements for their supply chain. That is to say, our goal will be to diversify, pursue minimum waste, higher value and faster speed to meet industry standards. However, the development of China's fresh agricultural supply chain is still far from that of developed

countries. Therefore, summed up China's new agrarian products supply chain respectively by processing enterprises, chain supermarkets, wholesale markets, new electrical business as the core of the four patterns, identify the potential risk of supply chain, from the production, supply and demand, logistics, cooperation, and put forward the relevant measures of risk prevention, in order to improve the operational efficiency of the supply chain, is an urgent task to related researchers and workers. The key factors affecting the overall operational efficiency of the supply chain of fresh agricultural products and the main ways to improve the efficiency are studied to coordinate the supply chain of fresh agricultural products.

2. LITERATURE REVIEW

2.1. Domestic Literature Review

Houqing (2013) used SCOR method to identify risks, then used Fuzzy Analytic Hierarchy Process (FAHP) to evaluate the risks, found out the information factors that had the greatest impact on the risks, established risk control model using option theory, and put forward corresponding control measures for the factors affecting agricultural products supply chain. Xuejiao (2016) believes that the post-supervision model of supply chain risk is not feasible and advocates risk prevention. Yanyan and Zheng. (2017) divided the dangers of the fresh agricultural products supply chain into internal threats brought by farmers, processing enterprises, dealers, consumers and other participants in the supply chain, information risks, logistics risks, credit risks formed between nodes, and external threats under the influence of natural environment and government policies. Peipei (2018) introduced the current status of Yatong, discussing the application model of the reinsurance company in risk identification, analyzing the risks of Yatong from four aspects, and further evaluating the risk comprehensive fuzzy evaluation method for each process. Zhenchun and Huizi (2018) analyzed agricultural product supply chain financial models from the perspective of farmers, leading enterprises, governments and guarantee institutions, identified risks, constructed agricultural product supply chain financial risk evaluation index system, and adopted fuzzy analytic hierarchy process. Assess potential threats, and the indicators that have the most significant impact on the chances are obtained, which provides a practical plan for financial institutions to avoid risks. Ting (2018) discussed the problems of too many circulation links in fresh agricultural products logistics, severe product losses, backward infrastructure, high logistics costs, low degree of informatization and organization, stagnant import and export of products, and severe brain drain. Diying (2018) uses a variety of disciplines and theories combined with a variety of scientific methods to study in-depth the supply chain of fresh agricultural products in Zhejiang Province in the production and processing enterprises, wholesale markets, supermarket chains, new business as the main four modes of fresh agricultural products supply chain management in Zhejiang Province, pointing out the main problems and adapting to the whole supply chain model.

2.2. Foreign Literature Review

Diabat *et al.* (2012) used the explanatory structure model (ISM) to analyze various risks in the food supply chain. Different types of risks were identified based on a review of the literature and consultations with food industry experts. Samvedi *et al.* (2013) evaluated the risk of the supply chain by combining fuzzy AHP model and fuzzy TOPSIS model, analyzed the necessary conditions for risk occurrence, and proposed risk countermeasures based on the above forming conditions. Xiang *et al.* (2013) explored the supply chain selection of the general model of the input level of the production supply chain, bilateral effects, supply uncertainty, quantitative analysis of agricultural supply chain risk quantitative analysis, found that all types of contracts need to accept coordinated supply chain random demand to reduce the risk of the supply chain. Song *et al.* (2017) studied the supply chain management based on the crude strength relationship analysis method, identified the key risk factors and applied it to the actual enterprise, and proved the practicability of the method. Nakandala *et al.* (2016) shows that due to the perishable nature of fresh agricultural products, it will face a variety of risks. This paper establishes a total cost

model by using genetic algorithms, fuzzy genetic algorithms and simulated annealing procedures to help relevant managers in the supply chain. Optimize cost decisions to ensure food quality and safety. Used game theory tools to study the influence of credit risk on price fluctuation in the supply chain, and proposed methods to improve service quality from various perspectives.

To sum up, different methods and different aspects of fresh agricultural products supply chain risk management are actively studied at home and abroad. Based on the research status at home and abroad, this paper further studies the risk management of fresh agricultural products supply chain by using fuzzy analytic hierarchy process, hoping to provide corresponding countermeasures and suggestions for the risk prevention of fresh agricultural products supply chain.

3. RISK IDENTIFICATION AND ASSESSMENT OF FRESH AGRICULTURAL PRODUCTS SUPPLY CHAIN

3.1. Fresh Agricultural Product Supply Chain Model

In order to better study the supply chain risk of fresh agricultural products, this paper focuses on analyzing the supply chain mode of fresh agricultural products, mainly including the following four ways:(1) Fresh agricultural products supply chain model with processing enterprises as the core. Processing enterprises rely on strong influence and reputation to connect upstream and downstream enterprises in the supply chain to build a supply chain system integrating production and sales. On the other hand, processing enterprises can provide technical and financial support for farmers, realize information sharing on the communication platform, establish long-term and steady cooperative relations, reduce farmers' planting risks caused by information asymmetry, and use the minimum input to ensure the stable supply of fresh agricultural products and maintain the balance of supply and demand market.(2) The supply chain model of fresh agricultural products with chain supermarkets as the core. This kind of supply chain is a unique model. The supermarket chain will become the organizer, intimately connecting the producers, distributors, and consumers in the supply chain. As an organizer, the supermarket will go deep into the production process, manage and supervise the production and processing of fresh agricultural products. This supply chain model is closely linked to producers and consumers at both ends through contracts, eliminating the distribution of middlemen, reducing transaction costs and making the supply chain more concise.(3) The fresh agricultural products supply chain model with the wholesale market as the core. The wholesale market is the core agricultural supply chain model, which means that the wholesale market plays a role in the entire supply chain, forming a bridge between pre-connection and behavior, passing through producers, retailers and consumers, collecting by upstream producers. A large number of urgently needed items, quickly distributed and passed through downstream retailers to meet consumer demand. (4) Fresh agricultural products supply chain model with fresh e-commerce as the core. This model integrates market resources and information. In order to improve the quality of service and promote the standardization process of fresh agricultural products, the standardization process of fresh agricultural products can be quickly traced back to the source. The door-to-door distribution of products can quickly meet customer needs, drive product sales, and facilitate government supervision. However, this model is applicable to first- and second-tier cities with high consumption levels and advanced consumption concepts, and also puts forward higher requirements for information management, transportation route planning, and cold chain logistics.

3.2. Fresh Agricultural Product Supply Chain Risk Category

Through the analysis of the four modes of the supply chain of fresh agricultural products in China, this paper understands the causes of risk factors under different modes, and summarizes six categories of risks based on the supply chain process.

(1) Production risk. ① Production management. The management of fresh produce is not strictly regulated,

and the implementation of regulations is not strict, resulting in the lack of good planting of fresh produce during the cultivation process, such safe and delicious fresh produce cannot meet the expected standards. ② Quality and safety. The farmers in the production process due to the improper operation caused adverse consequences. For example, the unreasonable use of toxic substances such as pesticides and fertilizers will cause the quality of fresh agricultural products to fail to meet the standards and affect consumers' health.

(2) Demand risk. ① Demand forecast. There are many middlemen in the upstream and downstream of the supply chain. The upstream information is inconsistent with the downstream information, which will lead to lack of information and increase farmers' planting risks. ② Demand fluctuation. The existence of the "bullwhip effect" gradually enlarges the demand in the supply chain, which leads to oversupply, resulting in a large amount of unnecessary inventory redundancy and increased waste. In addition to the perishable and perishable characteristics of fresh agricultural products, poor storage will increase the risk of supply chain. ③ Consumer preference. With the rapid development of science and technology, there are more and more kinds of fresh agricultural products on the market. Changes in consumer perceptions and lifestyles make it increasingly difficult to grasp consumer demand and preferences, leading to shortages or stagnation of fresh produce, creating certain risks.

(3) Supply risk. ① Delay delivery. There are two reasons for the delay in delivery: First, the supplier cannot provide the agreed quantity of fresh produce on time due to reduced production or unqualified quality. Second, there is the risk of delayed delivery caused by accidents such as earthquakes in the process of transportation. ② Supplier competition. In order to seek long-term cooperative relations, enterprises often establish long-term cooperation with fixed suppliers. If suppliers violate contract provisions due to credit problems, supply difficulties of enterprises will result in supply chain interruption risk.

(4) Cooperation risk. ① Profit distribution. Due to the weak sense of cooperation among the members of the supply chain, once the profit distribution is uneven, the cooperation will be terminated due to dissatisfaction, which will increase the operational risk of the entire supply chain. ② Information exchange between partners. To some extent, information sharing can improve the core competitiveness of enterprises. However, some supply chain members hide some information for their own interests, and information asymmetry increases supply chain risks. ③ Bad credit. In order to maintain a stable cooperative relationship, each node member in the supply chain will sign a contract at the beginning, stipulate the responsibilities and obligations of both parties, and the final proportion of interest distribution will be determined through negotiation between the two parties. However, due to the relationship between supply and demand, the price of fresh agricultural products has been fluctuating. Once the rate fluctuates too much, unqualified members often default to maximize their interests.

(5) Logistics risk. ① Backward cold chain technology. Fresh agricultural products need cold chain technical support in the circulation process. However, there is still a certain gap between China's cold chain technology and developed countries. The immature cold chain technology increases the loss of fresh agricultural products in the circulation process. ② Imperfect logistics infrastructure. China's logistics infrastructure is not perfect, it is not standardized in the process of transportation and stacking, the performance of transportation vehicles is low, the storage equipment is not updated in time, and the utilization rate of automation technologies such as RFID and EDI is low, which makes the logistics efficiency low, which leads to unnecessary waste. ③ Transport timeliness. Due to unreasonable distribution route planning of fresh agricultural products, multiple supply chain links, long transportation distance, and poor traffic conditions, fresh agricultural products suffer high losses in the transportation process.

(6) Environmental risk. ① Policies and regulations. Policies and rules promulgated by the government have significantly affected the development of fresh agricultural products industry. On the one hand, policy trends such as government support and preferential policies can have a significant impact on fresh agricultural products. On the other hand, incomplete legislation and implementation of relevant laws and regulations may restrict the development of the industry. ② The natural environment. The final quality of fresh produce will show different

states in different natural environments. Seasonal and climate changes will have a subtle influence on the cultivation of fresh produce. Although the application of science and technology can alleviate the adverse effects of the natural environment on agricultural products to a certain extent, the occurrence of natural disasters will increase the risk of the entire supply chain. ③ Market environment. Changes in the market environment will undoubtedly have a profound impact on the fresh agricultural products industry. The loose or tight economic environment has different effects on the fresh agricultural products industry, especially the emergence of financial crisis will further increase the supply chain risk.

3.3. Fresh Agricultural Product Supply Chain Risk Assessment

By analyzing the four modes of the supply chain of fresh agricultural products in China, we understand the causes of risk factors under different modes, and summarize six kinds of risks according to the supply chain process. The 16 indicators were used to establish the risk evaluation index system. Then the analytic hierarchy process was used to establish the fresh agricultural product supply chain evaluation model. Finally, the fuzzy analytic hierarchy process was used to evaluate the risk. This paper analyzes the questionnaire data for risk assessment, and puts forward corresponding risk management measures for high-risk factors, to improve the level of risk management.

i. Risk Identification

The risk of the supply chain of fresh agricultural products is affected by many factors. It is impossible to quantitatively analyze these factors by simple mathematical statistics method. In order to make the risk assessment of fresh agricultural product supply chain more accurate and useful, this paper determines the indicators through AHP. Weights and fuzzy analytic hierarchy process for final risk assessment. Specific indicators are shown in Table 1.

Table-1. Risk assessment index system for the fresh agricultural product supply chain.

Level indicators	The secondary indicators
Production risk B1	The production management C1
	Quality and safety C2
Demand for risk B2	Demand forecasting C3
	Demand fluctuations C4
	Consumer preference C5
Supply risk B3	Delay in delivery C6
	Supplier competition C7
Cooperation risk B4	Profit distribution C8
	Information communication C9
	Disqualification of credit C10
Logistics risk B5	Cold chain technology is backward C11
	Logistics infrastructure is not perfect C12
	Transport timeliness C13
Environmental risk B6	Policies and regulations C14
	The natural environment C15
	The market environment C16

ii. Risk Assessment

(1) Calculation of index weight. ① Construct judgment matrix.

$$B1=\begin{bmatrix} 1 & 5 \\ 1/5 & 1 \end{bmatrix} \qquad B2=\begin{bmatrix} 1 & 1/5 & 1/2 \\ 5 & 1 & 3 \\ 2 & 1/3 & 1 \end{bmatrix} \qquad B3=\begin{bmatrix} 1 & 1/4 \\ 4 & 1 \end{bmatrix}$$

$$B4=\begin{bmatrix}1 & 1/3 & 1/2\\ 3 & 1 & 2\\ 2 & 1/2 & 1\end{bmatrix}\quad B5=\begin{bmatrix}1 & 3 & 9\\ 1/3 & 1 & 3\\ 1/9 & 1/3 & 1\end{bmatrix}\quad B6=\begin{bmatrix}1 & 3 & 1/5\\ 1/3 & 1 & 1/7\\ 5 & 7 & 1\end{bmatrix}$$

$$B=\begin{bmatrix}1 & 1/3 & 3 & 3 & 1 & 3\\ 3 & 1 & 9 & 9 & 3 & 9\\ 1/3 & 1/9 & 1 & 1 & 1/3 & 1\\ 1/3 & 1/9 & 1 & 1 & 1/3 & 1\\ 1 & 1/3 & 3 & 3 & 1 & 3\\ 1/3 & 1/9 & 1 & 1 & 1/3 & 1\end{bmatrix}$$

② Consistency check.

Table-2. Consistency test results.

No.	λmax	Feature vector wi	CI	RI	CR	Whether consistency is satisfied
1	2.013	(0.833,0.167)	0.013	0	0.00012	Yes
2	3.005	(0.122,0.648,0.23)	0.0025	0.58	0.0043	Yes
3	2	(0.2,0.8)	0	0	0	Yes
4	3.01	(0.163,0.54,0.297)	0.005	0.58	0.0086	Yes
5	3	(0.692,0.231,0.077)	0	0.58	0	Yes
6	3.064	(0.188,0.081,0.731)	0.032	0.58	0.055	Yes
7	6.0003	(0.078,0.042,0.378,0.145,0.168,0.189)	0.0844	1.24	0.068	Yes

If R<0.1, it indicates that the judgment matrix meets the consistency requirement, and the eigenvector of the matrix can be used to represent the weight value, otherwise, the judgment matrix needs to be adjusted again. All R in the above table is less than 0.1, so they have passed the consistency test.

Table-3. Questionnaire results.

Risk indicator		Risk level				
Level indicators	**The secondary indicators**	**High**	**Higher**	**General**	**Lower**	**Low**
Production risk	Production management risk C1	0.2	0.2	0.2	0.3	0.1
	Quality and safety risk C2	0.3	0.1	0.2	0.2	0.2
Demand for risk	Demand forecasting risk C3	0.1	0.3	0.3	0.1	0.2
	Demand fluctuations risk C4	0.1	0.1	0.2	0.5	0.1
	Consumer preference risk C5	0.1	0.1	0.6	0.1	0.1
Supply risk	Delay in delivery risk C6	0	0.3	0.2	0.3	0.2
	Supplier competition risk C7	0	0.3	0.1	0.5	0.1
Cooperation risk	Profit distribution risk C8	0.3	0	0.3	0.3	0.1
	Information communication risk C9	0.3	0.3	0.1	0.2	0.1
	Disqualification of credit risk C10	0.1	0.3	0.2	0.3	0.1
Logistics risk	Cold chain technology risk C11	0.1	0.4	0.4	0.1	0
	Logistics infrastructure risk C12	0.1	0.2	0.3	0.3	0.1
	Transportation risk C13	0.3	0.1	0.1	0.3	0.2
Environmental risk	Policy and regulatory risk C14	0.1	0.2	0.2	0.2	0.3
	Natural environmental risk C15	0.2	0.2	0.3	0.1	0.2
	Market environmental risk C16	0.1	0.2	0.4	0.2	0.1

iii. Fuzzy Comprehensive Evaluation

(1) Raw data statistics. Based on using the analytic hierarchy process to obtain the index weight, 758 questionnaires were issued, and 509 valid questionnaires were recovered, with a recovery rate of 67.2%. Risk factors

were divided into five grades: high, higher, general, low, and lower. Questionnaires were collected for data statistics, and the final statistical results were shown in Table 3.

(2) Determining the fuzzy comprehensive evaluation matrix of the first-level indicators.

$$R1=\begin{bmatrix}0.2 & 0.2 & 0.2 & 0.3 & 0.1\\ 0.3 & 0.1 & 0.2 & 0.2 & 0.2\end{bmatrix} \quad R2=\begin{bmatrix}0.1 & 0.3 & 0.3 & 0.1 & 0.2\\ 0.1 & 0.1 & 0.2 & 0.5 & 0.1\\ 0.1 & 0.1 & 0.6 & 0.1 & 0.1\end{bmatrix}$$

$$R3=\begin{bmatrix}0 & 0.3 & 0.2 & 0.3 & 0.2\\ 0 & 0.3 & 0.1 & 0.5 & 0.1\end{bmatrix} \quad R4=\begin{bmatrix}0.3 & 0 & 0.3 & 0.3 & 0.1\\ 0.3 & 0.3 & 0.1 & 0.2 & 0.1\\ 0.1 & 0.3 & 0.2 & 0.3 & 0.1\end{bmatrix}$$

$$R5=\begin{bmatrix}0.1 & 0.4 & 0.4 & 0.1 & 0\\ 0.1 & 0.2 & 0.3 & 0.3 & 0.1\\ 0.3 & 0.1 & 0.1 & 0.3 & 0.2\end{bmatrix} \quad R6=\begin{bmatrix}0.1 & 0.2 & 0.2 & 0.2 & 0.3\\ 0.2 & 0.2 & 0.3 & 0.1 & 0.2\\ 0.1 & 0.2 & 0.4 & 0.2 & 0.1\end{bmatrix}$$

(3) Fuzzy analytic hierarchy analysis of first-level indicators.

$$Y1=W1\times R1=(0.833,0.167)\times\begin{bmatrix}0.2 & 0.2 & 0.2 & 0.3 & 0.1\\ 0.3 & 0.1 & 0.2 & 0.2 & 0.2\end{bmatrix}$$

$$=(0.2167,0.1833,0.2,0.2833,0.167)$$

The same is available:

$$Y2=(0.1,0.1244,0.3042,0.3592,0.1122)$$
$$Y3=(0,0.3,0.12,0.46,0.12)$$
$$Y4=(0.2406,0.2511,0.1623,0.246,0.1)$$
$$Y5=(0.1154,0.3307,0.3538,0.1616,0.0385)$$
$$Y6=(0.1081,0.2,0.3543,0.1919,0.1457)$$

(4) Comprehensive fuzzy hierarchy calculation.

$$Y=(0.078,0.042,0.378,0.145,0.168,0.189)$$
$$\times\begin{bmatrix}0.2167 & 0.1833 & 0.2 & 0.2833 & 0.167\\ 0.1 & 0.1244 & 0.3042 & 0.3592 & 0.1122\\ 0 & 0.3 & 0.12 & 0.46 & 0.12\\ 0.2406 & 0.2511 & 0.1623 & 0.246 & 0.1\\ 0.1154 & 0.3307 & 0.3538 & 0.1616 & 0.0385\\ 0.1081 & 0.2 & 0.3543 & 0.1919 & 0.1457\end{bmatrix}$$
$$=(0.0958,0.2974,0.2635,0.2245,0.1116)$$

iv. Analysis of Evaluation Results

According to the effects of fuzzy hierarchy calculation, we can draw the conclusion: the risk level of the fresh agricultural supply chain is higher. Among the primary indicators, supply risk accounted for 37.8% of the total, and

the impact on supply chain risk was the greatest, followed by 18.9% environmental risk, 16.8% logistics risk and 14.5% cooperation risk. There is a greater impact on the risk of the supply chain. The remaining is 7.8% of production risk and 4.2% of demand risk. These two risk factors have little impact on the risk of fresh agricultural product supply chain.

4. CONCLUSIONS AND IMPLICATIONS

Targeting various risks in the supply chain of fresh produce, this paper puts forward corresponding improvement measures as follows: (1) Production risk prevention. Strengthen the supervision of the production process of fresh agricultural products and establish the traceability system. Consumers can enter the system by scanning the code to see the whole process of fresh produce production, including seed selection, pesticide and fertilizer use, packaging and processing standards, etc. (2) Demand risk prevention. Information sharing platform shall be established to improve the level of informatization. The government shall strengthen supervision to prevent the release of invalid information and timely update information. (3) Supply risk prevention. Develop and select more agricultural products suppliers, and strictly require suppliers to conduct a comprehensive investigation on delivery rate, reputation, customer satisfaction, and other aspects to ensure timely supply and diversification of fresh agricultural products. (4) Cooperation risk prevention. Establish a good cooperative relationship of mutual trust between enterprises, benefit sharing, and win-win cooperation, and ensure the smooth operation of the supply chain. Establish a reasonable interest distribution mechanism, promote coordination and supervision of third parties, strengthen trust relationships among members of the supply chain, and jointly prevent cooperation risks. (5) Logistics risk prevention. Improve cold chain technology, introduce advanced facilities and equipment.(6) Environmental risk prevention. Real-time monitoring of external climate and market environment changes, making emergency plans in advance, strengthening emergency management, and comprehensively monitoring the external environment of the supply chain.

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