

Researches on Risk Evaluation of Green Agro-product Closed Supply Chain

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Abstract Closed supply chain is a superior form of management model of chain supply and an effective means of improving the modernization of agro-product circulation. Based on the research results of the current literatures on supply chain risk and agro-product supply chain, related subjects of the agro-product closed supply chain involving production, management and consumption are studied and analyzed and the primary risk factors in the supply chain system are classified as environmental risk, system risk, information risk, management risk and quality risk. Risk of agro-product closed supply chain is evaluated by using the method of fuzzy comprehensive evaluation and the values are acquired. The result shows that risk of agro-product closed supply chain is moderate with relatively high risk, which basically accords with the present actual situations. It can be seen from the index weights of various levels that the key first-level indices influencing the risks are system risk, information risk, quality and safety risk and the key second-level are the coordinating and controlling ability of core enterprises, the implementation of information traceability and the construction of quality safety system. Therefore, risk of agro-product closed supply chain should be reduced by taking prevention and controlling measures mainly from these aspects.

Key words Green agro-products, Closed supply chain, Risk evaluation, China

Closed supply chain is the superior among management forms of supply chain and the effective means of improving the modernization of agro-products circulation. Its key concept is to implement strict admission administration regulation, unified operating specification and technical standards among member enterprises of the supply chain, conduct real-time monitoring as well as dynamic tracking to form a traceable supply chain system with the goal of ensuring product safety and quality control, making sure that the whole procedure from production to consumption is under strict quality supervision in order to stabilize product quality during the circulation and control the damage of product quality safety problems to the maximum degree^[1]. Compared with open supply chain, closed supply chain has stronger maneuverability and compatibility, higher channel efficiency as well as higher ability of risk resistance. Establishing and perfecting the closed supply chain of green agro-products is beneficial to satisfying consumers' increasing demand of various, featured, fresh and healthy agricultural products, achieving the convergence of production and demand, guiding production, improving the quality and value of agro-products multi-dimensionally, ensuring consumption safety of agro-products, enhancing the efficiency and benefits of agro-product circulation and realizing the high-efficient operation of production,

processing, trading and logistics distribution of green agro-products^[2].

Because of the complicated procedure without integration of green agro-product supply chain, the increasingly complex structure and low standard of information sharing, the closed supply chain of agro-products is surely confronted with certain risks. With the growing attention on the circulation efficiency and quality safety of green agro-products, risk control in the establishment and operation of green agro-product closed supply chain has become an issue requiring urgent solution^[3]. Yet, current researches of the closed supply chain emphasize the connotation, system establishment, operating mode and costs control of closed supply chain and monographic studies on the risks of green agro-product supply chain are absent^[4]. Based on the analysis of risk factors of green agro-product closed supply chain, the index system comprehensively evaluating risks has been built. And risks of green agro-product closed supply chain have been evaluated through AHP-fuzzy comprehensive evaluation, which can provide support for risk control of green agro-product closed supply chain and improve the risk management of supply chain.

1 Index system and research methods

1.1 Index system As an effective organizational form, green agro-product closed supply chain stresses the maneuverability of circulation products in the whole operation management of supply chain in order to ensure the quality and safety of circulation products with the goal of achieving safe and reliable supply of related products through the management innovation of supply chain. Nevertheless, there are numerous uncertain influencing factors inevitably existing in the operation of green agro-product closed supply chain. These uncertain factors may

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stem from not only the outside of supply chain system, such as changes in market demand as well as uncertainty of policy environment but also the internal part of the system, such as the comprehensive coordinating and controlling ability of key enterprises, technical safety of production and processing as well as operating support capability of logistics distribution^[5]. Therefore, based on the research results of the current literatures on supply chain risk and agro-product supply chain, related subjects of the agro-product closed supply chain involving production, management and consumption are studied and analyzed and the primary risk factors in supply chain system can be classified as 8 categories, namely environmental risk, system risk, information risk, management risk and quality safety risk. Each kind of risk factor can be further divided into several determi-

nants and the details are shown in Table 1. The factor set of criteria level can be formulated as $U = \{U_1, U_2, U_3, U_4, U_5\}$ among which U_1 and U_2 refer to environmental risk and system risk respectively while U_3, U_4 and U_5 stand for information risk, management risk and quality safety risk respectively. The factor set of index level is formed with the assembling of index level factors corresponding to each factor in criteria level. For example, the factor set of index level is $U_1 = \{U_{11}, U_{12}, U_{13}, U_{14}, U_{15}\}$ among which U_{11} means perfection of relevant policies and regulations, U_{12} risk of changes in market demand, U_{13} completion of industrial chain of green agro-product closed supply chain, U_{14} perfection of reform of closed supply chain and U_{15} operation support capability of logistics distribution. Other factor sets of index level can be done with the same manner.

Table 1 Index system of risk evaluation of green agro-product closed supply chain

Target	Principle	Specific evaluation index	Code of indicator layer	
Supple chain overall degree of risk	Environmental risk U_1	Perfection of relevant policies and regulations	U_{11}	
		Risk of market demand change	U_{12}	
		Completion of industrial chain of green agro-product closed supply chain	U_{13}	
		Perfection of reform of closed supply chain	U_{14}	
		Operation support capability of logistics distribution	U_{15}	
	System risk U_2	Coordinating and controlling ability of core enterprises	U_{21}	
		Structure stability of supply chain	U_{22}	
		Network justifiability of supply chain	U_{23}	
		Information asymmetry	U_{31}	
		Information sharing	U_{32}	
	Information risk U_3	Implementation of information traceability	U_{33}	
		Management risk U_4	Equity of interest distribution	U_{41}
			Mutual confidence of main partners	U_{42}
	Effectiveness of risk response mechanism		U_{43}	
	Quality safety risk U_5	Technical security of production and processing	U_{51}	
Construction of quality safety system		U_{52}		
Quality safety of raw material from suppliers		U_{53}		

1.2 Research method

1.2.1 Establishment of index weight in criteria and index level
Five-level comment collection $V = \{v_1, v_2, v_3, v_4, v_5\} = \{\text{extremely strong, strong, relatively strong, ordinary, weak}\}$ is established by using five-level Likert Scale. The whole risks of closed supply chain of green agro-product are classified as 5 ranks which are converted into values. And scores in risk evaluation system of green agro-product closed supply chain are acquired through expert rating, which is shown in Table 2.

Table 2 Evaluating levels of risk

Level	Extremely high	High	Relatively high	Ordinary	Low
Numerical segment	(90,100]	(70,90]	(50,70]	(30,50]	[0,30]
Average value	95	80	60	40	15

With the method of analytic hierarchy process, relative materiality of indices in criteria level is estimated and the matrix established. Pairwise comparison of five first-level indices U_1, U_2, \dots, U_5 is conducted with 1-9 rating scale method proposed by Saaty and some others. Judgment matrix is acquired as $A = (a_{ij})_{n \times n}$ among which refers to the ratio of relative importance of element i and j , while n stands for number of indices. Matrix A is

normalized according to the column by using "sum-multiply" to gain matrix $\bar{A} = [\bar{a}_{ij}]_{n \times n}$ among which $\bar{a}_{ij} = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}}$. Elements in the columns of judgment matrix \bar{A} after normalization are added to get vector $W = [w_i]_n$ among which $w_i = \sum_{j=1}^n \bar{a}_{ij} (i=1, 2, \dots, n)$. Sum vector is conducted the normalization process to get weight vector $\bar{W} = [\bar{w}_i]_n$ among which $\bar{w}_i = \frac{w_i}{\sum_{i=1}^n w_i}$. And the acquired judgment matrix is conducted consistency check. The maximum eigenvalue of matrix A is calculated as $\lambda_{\max} = \sum_{i=1}^n \frac{[A \bar{W}]_i}{n(\bar{W})_i}$ among which $[A \bar{W}]_i$ means the number i element of vector $A \bar{W}$. Coincidence indicator is established as $C. I. = \frac{\lambda_{\max} - n}{n - 1}$ and coincidence ratio is calculated as $C. R. = \frac{C. I.}{R. I.}$ among which $R. I.$ (Random Index) stands for the average random coincidence index of the matrix from order 1 to 10. It can be accepted that judgment matrix A possesses satisfying consistency when $C. R. < 0.1$. And judgment matrix A should be rebuilt or revised when $C. R. > 0.1$.

1.2.2 Fuzzy comprehensive evaluation. Fuzzy comprehen-

sive evaluation is a method of evaluation quantizing those fuzzy factors which cannot be directly described by exact numbers and have no features of quantification through mathematical treatment in order to provide reference for scientific decision making of quantization^[6]. Closed supply chain of green agro-products is facing the problems of uncertainty of internal and external environment, system as well as information. Therefore, fuzzy comprehensive evaluation can be adopted to evaluate the risks of green agro-product closed supply chain caused by various uncertain factors. Fuzzy comprehensive evaluation of green agro-product supply chain is a fuzzy transformation from factor set U to comment set V . When the weight vector \bar{W} of a factor group is inputted, a set of corresponding judging result B can be acquired. First of all, single factor assessment of some single element $U_i (i=1, 2, \dots, m)$ of the element set U should be conducted and the membership grade of the factor to comment set V is defined from factor U_i , acquiring the single element evaluation set of the number i factor U_i as $\gamma_i = (\gamma_{i1}, \gamma_{i2}, \dots, \gamma_{in})$. Since each element of criteria level is determined by all elements of index level which is determined by criteria level, the single element evaluation of each element of criteria level is the multi-factor comprehensive evaluation results of all elements of criteria level. The single element evaluation matrix of criteria level is

$$R = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \dots & \gamma_{1n} \\ \gamma_{21} & \gamma_{22} & \dots & \gamma_{2n} \\ \vdots & \vdots & & \vdots \\ \gamma_{m1} & \gamma_{m2} & \dots & \gamma_{mn} \end{bmatrix}$$

The line number of matrix R is the number of indices and the column number stands for the number of comment level. γ_{ij} refers to the percentage of the j evaluation criterion in all evaluations conducted by the i index, which can be obtained through expert inquiry.

When the index weight A and fuzzy relation matrix R are given, A can be transformed into the fuzzy comprehensive evaluation set B of the comment set V through fuzzy linear relation in matrix R .

$$B = A \times R = (b_1, b_2, \dots, b_n) = [a_1, a_2, \dots, a_m] \times \begin{bmatrix} \gamma_{11} & \gamma_{12} & \dots & \gamma_{1n} \\ \gamma_{21} & \gamma_{22} & \dots & \gamma_{2n} \\ \vdots & \vdots & & \vdots \\ \gamma_{m1} & \gamma_{m2} & \dots & \gamma_{mn} \end{bmatrix}$$

In the formula, $b_j (j = 1, 2, \dots, n)$ means the membership grade of level (comment) v_j to fuzzy evaluation set B acquired after comprehensive evaluation. m and n refer to the number of indices and evaluation rating respectively. And stands for generalized fuzzy compositional operation.

2 Result and analysis

2.1 Index weight vector of criteria level and index level

The following is acquired according to weight computation.

Index weight of criteria level $\bar{W} = (0.059, 0.223, 0.206, 0.087, 0.425)$

Index weight of index level: Weight vector of environmental

risk factor $\bar{W}_{U1} = (0.315, 0.189, 0.165, 0.204, 0.127)$

Weight vector of system risk factor $\bar{W}_{L2} = (0.475, 0.284, 0.241)$

Weight vector of information risk factor $\bar{W}_{L3} = (0.471, 0.376, 0.153)$

Weight vector of management risk factor $\bar{W}_{U4} = (0.368, 0.284, 0.348)$

Weight vector of quality safety risk factor $\bar{W}_{L5} = (0.216, 0.453, 0.331)$

After inspection, each related evaluation judgment matrix < 0.1 . Therefore, weight passes consistency test and evaluation result is reliable.

2.2 Result of fuzzy comprehensive evaluation Vector of fuzzy comprehensive evaluation of index level is acquired through the method of fuzzy comprehensive evaluation.

$$B_{U1} = (0.172, 0.240, 0.339, 0.203, 0.046)$$

$$B_{L2} = (0.212, 0.234, 0.098, 0.153, 0.303)$$

$$B_{L3} = (0.192, 0.302, 0.222, 0.082, 0.202)$$

$$B_{U4} = (0.235, 0.143, 0.043, 0.210, 0.369)$$

$$B_{L5} = (0.304, 0.234, 0.034, 0.295, 0.149)$$

The secondary fuzzy comprehensive evaluation is conducted in order to get fuzzy comprehensive evaluation of criteria level and the judgment set is

$$B = \bar{W} \cdot R = \bar{W} \cdot \begin{bmatrix} B_{U1} \\ B_{L2} \\ \vdots \\ B_{L5} \end{bmatrix} = (0.246, 0.240, 0.106, 0.206,$$

0.202)

Fraction set (the adopted fraction set is the mid-value of the rating) is introduced from Table 2 $V_w = (95, 80, 60, 40, 15)^T$ to get the value of fuzzy comprehensive evaluation of green agro-product closed supply chain.

$$F = V_w^T \cdot B = (95, 80, 60, 40, 15)^T \cdot (0.246, 0.240, 0.106, 0.206, 0.202) = 60.24$$

3 Conclusion

Based on the result of fuzzy comprehensive evaluation and the classification of risk rating, the risk of green agro-product closed supply chain is moderate, involving relatively high risk, which basically accords with the present actual situations. It can be seen from the index weights of various levels that the key first-level indices influencing the risks are system risk, information risk, quality and safety risk and the key second-level are the coordinating and controlling ability of core enterprises, the implement of information traceability and the construction of quality safety system. Therefore, risk of agro-product closed supply chain should be reduced by taking prevention and controlling measures mainly from these aspects.

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current wholesale market. They should increase the integration efforts, thoroughly changing the situation that each does things in his own way and overlapping management. By integrating the agricultural wholesale market, the government can develop scale economy and improve production efficiency effectively^[4]. In the process of development, the wholesale market should give full play to the main role and drive the development of related industry smoothly, thus promoting the scale expansion effectively. We should develop "wholesale market + rural households" in the form of industrial management of agriculture and connect agricultural production with the market. By adopting this from of industrial management of agriculture, we can effectively join storage, transportation and other links as an organic whole, thus achieving the integration of industry channel and driving the development of related industry before and after effectively. This is an inevitable path by which wholesale markets survive and develop in the management of commercialization.

4.3 Develop the circulation cooperatives of agricultural products The emergence of various types of cooperative organizations of farmers has played a positive role in guiding the main body of the agricultural production to better blend into the market. In the process of development of agricultural marketing channels, we should promote the pace of the regional and specialized agricultural production continuously and give full play to the industrial advantages of each region, thus providing a good environment for the development of all types of farmer cooperative organizations^[5]. Meanwhile, with the increase of people's income in China, people's consumption needs for the market structure has undergone some changes, and the further processing of agricultural products has become an important source for adding the value of agricultural products. We need to develop the processing, storage and other business of agricultural products, extend the development of agricultural industrialization effectively, improve the comparative advantage of agriculture, return the profits of the processing and sale to the farmers, thus effectively promoting the balanced development of the market. The government should guide cooperative organizations, which has a certain management ability, to develop toward an integrated direction and to develop from a single sales function to pre-production information service and other diversified functions. According to the changes of the market demands, agricultural producers should take the mode of diversified operation and develop the processing industry of agricultural products vigorously. This is an inevitable route for the circulation cooperatives of agricultural products to expand their scale.

4.4 Develop the integrated organization of production and sales of agricultural products The integrated production and sales of agricultural products is the newborn thing of the social development and it plays an important role in promo-

ting the economic development of the countryside. It takes the market development as the orientation and the processing enterprises as the main body. It conducts full integration and forms a perfect industry system by promoting and applying science and technology, thus achieving the agricultural operation mode of integrated agricultural products. In the process of actual development, the government has to train some leading enterprises, which have certain technical level, production scale and leading capacity, to break the traditional administrative management system, give full play to the industrial advantage of leading enterprises, achieve the optimal allocation of factor resources such as capital, technology and talents, and enhance the capacity of the agricultural production organization to resist risk. The organization should establish a sound internal management system, reduce internal management cost effectively, and accelerate the achievement of scale economy. We should establish a scientific and reasonable connection mode and distribution mechanism of interest, so that enterprises and farmers can be connected effectively, thus achieving the steady development of integrated production and sales of agricultural products. We should also make clear the connection method and the interest distribution way between the leading enterprises and farmers, make clear the rights and responsibility between both sides, standardize and institutionalize the interest-share mechanism of integrated production and sales of agricultural products, thus protecting the legitimate rights and interests of subjects effectively. At the same time, we should increase the innovation research of all kinds of organizations, improve the production standard effectively and promote the development of the agricultural product market by combining all kinds of innovation strategies so that we can promote the development of new socialist countryside.

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