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Research on Risks Evaluation of the Agricultural Products Supply Chain

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Abstract: Due to the diversity and complex nature of agricultural products buthere are huge possible risks in agricultural products supply chain. The agricultural products supply chain has complex structure, uncertain market, imbalanced and vulnerable market power. Its risks generally originate from technique, information, organization management and security. From the view of endogenous and exogenous risks buthis paper establishes a risks-assessing system composed of 20 indicators. Through methods of AHP and fuzzy comprehensive evaluation with Chinese data, risks of agricultural products supply chain can be evaluated. A numerical example illustrates its applicability and some appropriate suggestions on risks management are put forward according to the risk assessment results.

Key words: Supply chain, risks , fuzzy comprehensive evaluation

INTRODUCTION

Agricultural products supply chain is not only demand chain but also a function network made up of various individual agricultural production operators, wholesalers, retailers and final consumers. Because individual agricultural production operators are numerous and comparatively dispersive buthere are too many intermediate links in it buthus agricultural supply chain is short of uniform collaboration. For small farmer production it is relatively difficult to achieve scope effect and realistic benefit. The major farmers do not take part in and boost the agricultural operation integration of production-supply-sale but severally get into the market with larger market risks which generates the exposure and fragility of supply chain (Prater *et al*., 2001;Wang and Zhang, 2009).

Agricultural products supply chain has special distinction such as market uncertainty, structural complexity, imbalance of market power and vulnerability. In each link of the chain there are many participants as suppliers, wholesalers, retailers and customers of the agricultural production materials from place of origin to place of consumption, including seeds, fertilizers, pesticides, agricultural machinery and other production materials wholesalers, retailers, individual farmers, agricultural products wholesale market buthe retail terminal and the final consumer (Ahumada and Villalobos, 2009). There are time and spatial difference in agricultural production and consumption and information of market is very decentralized and full of uncertainty, whether or not individual farmers and processing enterprises buthey are difficult to fully catch the market supply and demand information (Van der Vorst, 2006). Due to small farmers' operation the farmers market are scattered and results in weak strength. In the agricultural products supply chain, logistics availability such as transportation, packaging and warehousing capacity greatly determines not only the speed and scale but also depth and breadth of agricultural products circulation. Currently, Chinese agricultural product prices are climbing substantially, on one hand it is affected by the macro social and economic environment. On the other hand, destruction of some links such as agricultural production and transportation results in the imbalance of supply chain system which can not come into play a normal supply function and therefore these supply chain shows a greater vulnerability in operation mechanism and its own structure.

Agricultural supply chain risks mainly represent the technical, informational, organizational and quality safety risks. According to China government statistics, about 28% of China's fruits, vegetables and other farm produce decompose in logistics process such as picking butransportation and storage and the annual loss gross is more than 18 billion U.S. dollars. Chinese logistics technologies is rather backward nowadays and suffers sever loss and risk to the whole supply chain (Shen, 2011). At present, overall information level of Chinese agricultural supply chain is relatively low, so nodes of supply chain lack information sharing with each other. In current circulation mode of farming products, wholesale market sits at the heart of chain. But the trading mechanism promotes the establishment of competition relationship between sellers and buyers

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rather than cooperation which causes lack of strategic cooperation within nodes of chain buthe information asymmetry of the trading parties and seriously restricting the integration possibility of the whole chain. As for agricultural quality safety, although Chinese government carried out massive construction of food quality safety system since 2001 and has still not completely set up a standard food inspection and testing system, as well as food quality safety evaluation system butherefore agricultural supply chain has the relatively higher quality safety risk. The aim of this research is to establish an risks assessment framework on agricultural products supply chain in China.

EVALUATION INDICATOR FRAMEWORK

Index description: In the study, endogenous and exogenous dimensions are presented to define supply chain risks. Endogenous risks of agricultural products supply chain are hinge on four principles such as quality risks, management risks butechnique risks and logistics risks. And quality risks refer to product deterioration rate and hazardous substance residue rate. Management risks include information sharing degree and the degree of farmer participation and vendors cooperation. Technique risks mainly include applicability risks and advanced nature risks of agrotechny technology. Transport risks, distribution risks and inventory risk are deemed to logistics risks.

Exogenous risks of agricultural products supply chain are divided into natural environment, marketing environment and policy environment of supply chain. Natural environment can be illustrated as variability of agricultural seed, climate impact and accidental disasters. Market environment depend on the market acceptance of agricultural products, seasonality and economic cycle. Agricultural policy environment refer to the risks of agri-related preferential policy and logistics industry policies.

Indicators weight determination: In this paper, analytic hierarchy process is adopted to determine the indicators' weight. Firstly, expert questionnaire was designed to gain comparison matrix. Then ten valid questionnaires were dispatched and returned. On the basis of the importance degree, comprehensive assessment on the opinions of each indicator obtained the double comparison matrix of all indicators.

The various weights of indicators are calculated with the geometric average method. First level of endogenous risks named A is 0.833 and exogenous risks named B is 0.167. Weighting factors of relative indicators are shown as Table 1. The formula to determine largest eigenvalues of judgment matrix are listed as follows:

$$\lambda_{max}(A)=\sum_{i=1}^{n}\frac{(AW)_i}{nW_i}=4.0415 \qquad (1)$$

$$\frac{CR(A)=(\lambda_{max}-n)}{(n-1)=0.0138} \qquad (2)$$

$$CR(A) = CI/RI = 0.0015<0.10 \qquad (3)$$

So the judgment matrix has satisfactory consistency Similarly:

$$\lambda_{max} = (B) = 0.0415 \qquad (4)$$

$$CI(B) = 0.0325 \qquad (5)$$

$$CR(B) = 0.0056<0.10 \qquad (6)$$

So the judgment matrix has same satisfactory consistency. Similarly buthe weight of factors in third level relative to the second level can be calculated and results shown in Table 2.

A11 represents qualified rate for hazardous substance residual. A12 represents agricultural product deterioration

Table 1: Index weight(first and second level)

First factor	Second factor	Relative weight
A: Endogenous risks (weight 0.833)	A1: Quality risks	0.078
	A2: Management risks	0.201
	A3: Technical risks	0.201
	A4: Logistics risks	0.52
B: Exogenous risks (weight 0.167)	B1: Market risks	0.731
	B2: Natural environment	0.188
	B3: Policy environment	0.081

Table 2: Index weight(second and third level)

Second factor	Third factor	Relative weight
A1:Quality risks	A11:qualified rate for hazardous substance residual	0.75
	A12:Agricultural product deterioration rate	0.25
A2: Management risks	A21: Information sharing rate	0.600
	A22: Farmer participation degree	0.200
	A23: Vendors cooperation degree	0.200
A3: Technical risks	A31:Advanced risk for processing technology	0.500
	A32: Applicability risk	0.500
A4: Logistics risks	A41:Transportation risk	0.200
	A42:Distribution risk	0.600
	A43: Inventory risk	0.200
B1: Market risks	B11: Market acceptance degree	0.258
	B12: Seasonality	0.637
	B13:Economic cycle	0.105
B2: Natural environment	B21: Seed variability and climate influence risk	0.500
	B22: Incident risk	0.500
B3: Policy environment	B31: Agriculture-related preferential policies risk	0.250
	B32: Logistics industry policies risk	0.75

Table 3: Total index and weight

First factor (weight)	Second factor (weight)	Third factor (weight)	Weight
A (0.833)	A1 (0.078)	A_{11} (0.750)	0.049
		A_{12} (0.250)	0.016
	A2 (0.201)	A_{21} (0.600)	0.100
		A_{22} (0.200)	0.033
		A_{23} (0.200)	0.033
	A3(0.201)	A_{31} (0.500)	0.084
		A_{32} (0.500)	0.084
	A4:(0.520)	A_{41} (0.200)	0.087
		A_{42} (0.600)	0.260
		A_{43} (0.200)	0.087
B(0.167)	B1: (0.731)	B_{11} (0.258)	0.031
		B_{12} (0.637)	0.078
		B_{13} (0.105)	0.013
	B2 (0.188)	B_{21} (0.500)	0.016
		B_{22} (0.500)	0.016
	B3 (0.081)	B_{31} (0.250)	0.004
		B_{32} (0.750)	0.010

rate. A21 represents information sharing rate. A22 represents farmer participation degree. A23 represents vendors cooperation degree. A31 represents advanced risk for processing agriculture product circulation. A32 represents risk of applicability. A41 represents transportation risk. A42 represents distribution risk. A43 represents inventory risk.

B11 represents market acceptance degree. B12 represents seasonality. B13 represents economic cycle. B21 represents seed variability and climate influence risk. B22 represents incident risk. B31 represents agriculture-related preferential policies risk. B32 represent logistics industry policies risk. Similarly, satisfactory consistency of each matrix can be tested by calculation of CR.

Let the weight of second level factor relative to first level multiplied by the weight of first level factor relative to the total goal then the weight of second level factor relative to the total goal can be calculate. As the same way, let the weight of third level factor relative to second level multiplied by the weight of second level factor relative to the total goal, we can get the weight of second level factor relative to the total goal. So the total index and weight can be shown as Table 3.

FUZZY COMPREHENSIVE EVALUATION

Establishment of evaluation set: The experts from industry and universities were invited to evaluate each risk according to their own research and understanding. Then the risks indicators can be qualified (evaluation table omitted here). For the sake of convenience for expert group to assess each indicator in the indicator framework, a five-level reviews set V was applied.

V = {very low, low, medium, high, very high} buthe corresponding value is respectively 2,4,6,8,10.

Let YA1 present evaluation judgment matrix of quality risk; YA2 present information management risks, YA3 present technical risks, YA4 present logistics risks. Let YB1 present market environment risks; Let YB2 present natural environment risks and YB3 present policy environment risks. These could be produced as follows:

$$Y_{A1} = \begin{bmatrix} 0 & 0 & 0.3 & 0.5 & 0.2 \\ 0 & 0.2 & 0.2 & 0.4 & 0.2 \end{bmatrix}$$

$$Y_{A2} = \begin{bmatrix} 0 & 0.3 & 0.2 & 0.3 & 0.2 \\ 0 & 0.1 & 0.5 & 0.4 & 0 \\ 0 & 0 & 0.4 & 0.3 & 0.3 \end{bmatrix}$$

$$Y_{A3} \begin{bmatrix} 0 & 0.4 & 0.5 & 0.1 & 0 \\ 0 & 0.2 & 0.1 & 0.4 & 0.3 \end{bmatrix}$$

$$Y_{A4} = \begin{bmatrix} 0 & 0.2 & 0.2 & 0.3 & 0.3 \\ 0.1 & 0.1 & 0.5 & 0.2 & 0.1 \\ 0 & 0.1 & 0 & 0.6 & 0.3 \end{bmatrix}$$

$$Y_{B2} = \begin{bmatrix} 0.4 & 0 & 0.3 & 0.2 & 0.1 \\ 0 & 0.5 & 0.4 & 0.1 & 0 \end{bmatrix}$$

$$Y_{B1} = \begin{bmatrix} 0 & 0.1 & 0.4 & 0.2 & 0.3 \\ 0 & 0.4 & 0.2 & 0.2 & 0.2 \\ 0 & 0.3 & 0.4 & 0.3 & 0 \end{bmatrix}$$

$$Y_{B3} = \begin{bmatrix} 0.2 & 0.1 & 0.1 & 0.5 & 0.1 \\ 0.1 & 0.3 & 0.4 & 0.2 & 0 \end{bmatrix}$$

Comprehensive evaluation: Then we calculate the relevant scores of the comprehensive evaluation. Due to:

$$H_k = W_k * D_k \tag{7}$$

$$D_{A1} = Y_{A1} * u = \begin{bmatrix} 0 & 0 & 0.3 & 0.5 & 0.2 \\ 0 & 0.2 & 0.2 & 0.4 & 0.2 \end{bmatrix} * \begin{bmatrix} 2 \\ 4 \\ 6 \\ 8 \\ 10 \end{bmatrix} = \begin{bmatrix} 7.8 \\ 7.2 \end{bmatrix}$$

Similarly:

$$D_{A2} = \begin{bmatrix} 6.2 \\ 6.6 \\ 7.8 \end{bmatrix}$$

$$D_{A3} = \begin{bmatrix} 5.4 \\ 7.6 \end{bmatrix}$$

$$D_{A4} = \begin{bmatrix} 7.4 \\ 6.2 \\ 8.2 \end{bmatrix}$$

$$D_{B2} = \begin{bmatrix} 5.2 \\ 5.2 \end{bmatrix}$$

$$D_{B1} = \begin{bmatrix} 7.4 \\ 6.4 \\ 6 \end{bmatrix}$$

$$D_{B3} = \begin{bmatrix} 6.4 \\ 5.4 \end{bmatrix}$$

W_{A1} = [0.75 0.25]
W_{A2} = [0.6 0.2 0.2]
W_{A3} = [0.5 0.5]
W_{A4} = [0.2 0.6 0.2]
W_{B1} = [0.258 0.637 0.105]
W_{B2} = [0.5 0.5]
W_{B3} = [0.25 0.75]

Thus the comprehensive evaluation value of the quality risk is as follows:

$$H_{A1} = W_{A1} * D_{A1} = \begin{bmatrix} 0.75 & 0.25 \end{bmatrix} * \begin{bmatrix} 7.8 \\ 7.2 \end{bmatrix} = 7.65$$

Similarly, we can get other agricultural product supply chain risk factors evaluation value as follows: organization and management risk assessment value as follows:

$$H_{A2} = 6.6$$

Technical risk assessment value as follows:

$$H_{A3} = 6.5$$

Logistics risk evaluation value as follows:

$$H_{A4} = 6.84$$

Market environment evaluation value as follows:

$$H_{B1} = 6.616$$

Environment evaluation value as follows:

$$H_{B2} = 5.2$$

$$W = (0.065 \quad 0.167 \quad 0.167 \quad 0.433 \quad 0.122 \quad 00.31 \quad 0.014)$$

$$H_i = (7.65 \quad 6.6 \quad 6.5 \quad 6.84 \quad 6.616 \quad 5.2 \quad 5.65)$$

So the comprehensive risk score of the agricultural products supply chain is as follows:

$$H = W * H_i = 6.694$$

Based on the supply chain risk assessment score, we can judge above chain is placed in a status of slightly high risk. The assessment score of above supply chain risk evaluation iss 6.694 points, namely the general risk is placed in the status of slightly high side. Among the values, agricultural products quality risk ranks with a score of 7.65 which means the higher original source risks, because of the higher risks of hazardous substance residual (a score of 7.8).

Organization and management risk is in the status of general but slightly higher risk (ranked with a score of 6.6), in which vendor cooperation degree risk scores is relatively high.

Technical risk of agricultural products is in the status of the general risk with a score of 6.5, in which risk in applicability of processing technology for agricultural product circulation is relatively high with a score of 7.6. Logistics risk of agricultural products is in the status of the general and little higher risk with a score of 6.84, in which risk in agricultural product inventory is relatively higher with a score of 8.2, namely vegetables tend to be extruded and damages in storage.

Market risk of agricultural products is in the status of the general and little higher risk with a score of 6.161, in which market acceptance risk is higher. And agricultural natural environment and policy environmental risks are relatively low with a score of 5.2 and 5.65, mainly due to the failure to fulfill the farmers preferential policies promulgated, although this has a little impact on the operation of supply chain.

CONCLUSION

As a conclusion, we can find that there is a huge potential risk on agricultural product supply chain because of the specific complex nature of agricultural products. And agricultural product supply chain has such character as structural complexity, market uncertainty, market power imbalance and vulnerability. There are endogenous and exogenous dimensions to analyze risks of agricultural product supply chain. Endogenous risks of agricultural product supply chain are divided into agri-food quality risks, management risks and technical risks and logistics risks. Exogenous risks of agricultural product supply chain are hinge on three principles such as marketing environment, natural environment and policy environment of agricultural product supply chain. We establish a risk evaluation index system based on endogenous and exogenous dimensions of risks. The risks can be evaluated compositely with AHP and fuzzy comprehensive evaluation methods. A numerical example showed such method applicable to the evaluation of agricultural product supply chain risks and the appropriate measurement of risks management are proposed according to the risk assessment results.

In order to reduce the risk of agricultural product supply chain it is essential to take the measures as follows: to establish strategic cooperative partnership of supply chain; to carry out the new agricultural product quality safety superintend pattern to improve supervision level; to increase investment on infrastructure, refrigerated vehicles and technology; to establish agricultural information system. At the same time buthe quarantine inspection of hazard substance from agricultural products growth process should be strengthened to ensure the quality and safety of agricultural products.

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