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Research on the Supply Chain risk Assessment of the Fresh Agricultural Products based on the Improved TOPTSIS Algorithm

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The fresh agricultural products are easy to be perishable. During the transport and the storage, they are prone to be deterioration and damage. These risks bring to the great risk to the fresh agricultural products. Therefore, the fresh agricultural products have the very demand for the supply chain. At the same time, the supply chain of the fresh agricultural products in China is in the transition period. During the process of the transition, there will be a series of the unexpected questions. Therefore, it is very necessary to evaluate the supply chain risk. In this paper, in order to overcome the question that the weights of the TOPSIS method are influenced subjectively, we combine the improved entropy method with the TOPSIS method and propose the improved TOPSIS method. Then, we use the method to study the supply chain risk evaluation of the fresh agricultural products.

1. Introduction

The fresh agricultural products in China are in the critical period from the traditional supply chain of the fresh agricultural products to the modern agricultural products supply chain. The application of the new technology and the new supply chain operation mode promotes the value of the fresh agricultural products supply chain and reduces the traditional supply chain ris(Atallah et al., 2014). At the same time, it also brings the new risk (Ge et al., 2015).

The fresh agricultural products are the basic consumer goods in the people’s life (Chen et al., 2016). However, in recent years, the food safety accidents happened frequently. The consumers paid more attention to the food safety. These factors caused that the supply chain of the fresh agricultural products to be more attention (Perdana, 2012). The circulation supply chain of the fresh agricultural products was weak. The resistance risk ability of the supply chain was also not strong (Noya, 2016). In addition, the agricultural products had the certain particularity. There were many agricultural products needing to be disposed during the process of the circulation (Nong and Pang, 2013)). At the same time, the rural infrastructure was not perfect. The logistics network was difficult to be covered fully. It made that the circulation cost is higher. These factors made the supply chain of the fresh agricultural products face with a great risk. Therefore, it was very necessary to evaluate the supply chain risk of the fresh agricultural products.

TOPSIS method was a common method (Jayakumar and Venkatesh, 2014). The method used the distance of the evaluated objects between the positive ideal solutions to the negative ideal solutions (Vinodh et al., 2014). TOPSIS method can not only apply the small scale evaluation object (Othman et al., 2015), but also can apply the bigger system evaluation object (Peter et al., 2015). At the same time, the method had the good application in the horizontal comparison and vertical comparison. TOPSIS method had applied in many fields. For example, it has applied to the choice of the supply chain (Francisco et al., 2014), the safety risks management (Mahdevari et al., 2014) and the traffic congestion (Yu et al., 2013).

This paper analyzes the factors that the supply chain risk of the fresh agricultural products faced and proposes the supply chain risk evaluation indexes of the fresh agricultural products. Aiming at the question that the weights of the TOPSIS method are influenced by the subjective, this paper proposes the improved TOPSIS method. Finally, we apply the method to evaluate the supply chain risk of the fresh agricultural products.

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2. Supply chain risk evaluation system of the fresh agricultural products

There are many factors influencing the supply chain risk of the fresh agricultural products (Jacxsens et al., 2010). According to the base of identifying the supply chain risk of the fresh agricultural products, the system principle, the feasibility principle and the comparison principle, we refer to the literatures at home and abroad and compare with the features of the supply chain risk of the fresh agricultural products. Then, we design the supply chain risk evaluation system of the fresh agricultural products. The supply chain risk evaluation system of the fresh agricultural products is as follows.

Table 1: Supply chain risk evaluation system of the fresh agricultural products

First order index	Second order index	Third order index
Supply chain risk evaluation system of the fresh agricultural products	Internal risk	Risk in choosing suppliers and dealers
		Quality risk of the fresh agricultural products
		Technical risk
		Risk of deterioration for the fresh agricultural products
		Risk management decision
		Quality of supply chain risk
		Structure of the supply chain risk
	External risk	Credit risks
		Market environment risk
		Demand fluctuation risk
		Supply fluctuation risk
		Natural risk
		Policy risk
		Cooperation risk
	Logistics risk	Transportation risk
		Distribution of risk
		Inventory risk
	Information risk	Information transfer risk
		Information security risk

3. The improved TOPSIS method

TOPSIS method is a statistical analysis method (Lourenzutti et al., 2016). According to construct the ideal solution and the negative ideal solution of the decision problem, the method make the distance that be far away from the negative ideal solution and approach the ideal solution as the decision criterion. It orders the evaluation objects and makes the final decision (Mir et al., 2016). The weights of the TOPSIS method are dependent largely on the experts' opinions. It is subjected by the level of the expert knowledge and the experience. In addition, it is also easy to be influenced by the expert preferences and has the strong subjective (Krohling et al., 2015). Therefore, we improve the entropy method and combine with the TOPSIS method. Then, we propose the improved TOPSIS method. The method can reduce the subjective factors in the decision-making process and make the decision process more standardized. The decision steps of the improved TOPSIS method are as follows.

(1) According to the data information of the evaluation object, we give the index value for each evaluation index. Then we list the initial matrix. That is, the initial data matrix is,

$$(M_{ij}) = \begin{pmatrix} M_{11} & M_{21} & \cdots & M_{m1} \\ M_{12} & M_{22} & \cdots & M_{m2} \\ \vdots & \vdots & \ddots & \vdots \\ M_{1n} & M_{2n} & \cdots & M_{mn} \end{pmatrix} \tag{1}$$

The differences of the index value M_{ij} of each M_j in the initial index data $(M_{ij})_{mn}$ are bigger. It shows that the information quantity is more. Its effect in the performance evaluation is greater. If the differences of the indexes are smaller, it shows that the information quantity is little. Its effect in the performance evaluation is greater.

(2) We use the vector normalization method to standardize the decision matrix and get the normalized matrix.

$$(P_{ij})_{mn} = \begin{pmatrix} P_{11} & P_{21} & \cdots & P_{m1} \\ P_{12} & P_{22} & \cdots & P_{m2} \\ \vdots & \vdots & \ddots & \vdots \\ P_{1n} & P_{2n} & \cdots & P_{mn} \end{pmatrix} \tag{2}$$

Where, $P_{ij} = \dfrac{M_{ij}}{\sum_{i=1}^{m} M_{ij}}$

(3) According to the characteristics of the index, we pre-process the evaluation indexes. If the evaluation index is the positive index, it enters the next step. If the evaluation index is the negative index, we need to reverse the index to the positive index.

$$x'_{ij} = \max_{1\le i\le m} x_{ij} + \min_{1\le i\le m} x_{ij} - x_{ij} \tag{3}$$

This transformation is to transform the reverse index to the positive index according to $\max_{1\le i\le m} x_{ij} - x_{ij}$. The transformation of $+\max_{1\le i\le m} x_{ij}$ is according to the translation.

(4) In order to eliminate the difference between dimensions, we use the standardized treatment method to make the non-dimensional treatment for the evaluation index x'_{ij}.

$$\hat{x}_{ij} = (x'_{ij} - \mu_j)/\sigma_j \tag{4}$$

(5) In order to eliminate the partial negative value, we can translate the index value after the non- dimensional. We translate and transform $\hat{x}_{ij}$.

$$x''_{ij} = \hat{x}_{ij} + k \tag{5}$$

k is the translation range. We note x''_{ij} as x_{ij}.

(6) We calculate the index proportion.

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{6}$$

If the differences of the index value x_{ij} are bigger, it shows that the effect of the index is bigger than the evaluated object. It provides the more abundant information.

(7) Calculating the entropy value e_j, if the differences of the index value x_{ij} are smaller, the entropy value e_j is bigger.

$$e_j = -\frac{1}{Inm} \sum_{i=1}^{m} p_{ij} Inp_{ij} \tag{7}$$

Where, $k > 0$, $0 < e_j < 1$

(8) Calculating the entropy value of the index,

$$w_j = \frac{1 + \frac{1}{Inm} \sum_{i=1}^{m} p_{ij} Inp_{ij}}{\sum_{j=1}^{n} (\frac{1}{Inm} \sum_{i=1}^{m} p_{ij} Inp_{ij})} \tag{8}$$

The difference coefficient is,

$$g_j = 1 - w_j \tag{9}$$

(9) The weight of each index is,

$$X_j = \frac{g_j}{\sum_{j=1}^{n} g_j} \tag{10}$$

(10) Constructing the weighted normalized matrix. Because the importance of each evaluation index is different, we should consider the weights of each index. We weight the normalized data and transform it to the weighted normalized matrix.

$$V = (X_j P_{ij})_{mn} \tag{11}$$

That is,

$$V = (v_{ij})_{mn} = \begin{pmatrix} X_1 P_{11} & X_1 P_{21} & \cdots & X_1 P_{m1} \\ X_2 P_{12} & X_2 P_{22} & \cdots & X_2 P_{m2} \\ \vdots & \vdots & \ddots & \vdots \\ X_n P_{1n} & X_n P_{2n} & \cdots & X_n P_{mn} \end{pmatrix} \tag{12}$$

(11) Determining the positive ideal solution and the negative ideal solution of each index of the evaluated object.

$$V^+ = \left\{ (\max_{1 \le j \le m} v_{ij} \mid j \in J_1), (\min_{1 \le j \le m} v_{ij} \mid j \in J_2) \right\} \tag{13}$$

$$V^- = \left\{ (\min_{1 \le j \le m} v_{ij} \mid j \in J_1), (\max_{1 \le j \le m} v_{ij} \mid j \in J_2) \right\} \tag{14}$$

Where, J_1 is the benefit index. J_2 is the cost index. V^+ is the positive ideal solution and the negative ideal solution of the benefit index. V^- is the positive ideal solution and the negative ideal solution of the cost index.
(12) Calculating the Euclidean distance between the evaluation object to the positive ideal solution and between the evaluation object to the negative ideal solution.

$$d_i^+ = [\sum_{j=1}^{n} (v_{ij} - v_j^+)^2]^{\frac{1}{2}} \tag{15}$$

$$d_i^- = [\sum_{j=1}^{n} (v_{ij} - v_j^-)^2]^{\frac{1}{2}} \tag{16}$$

(13) Determining the relative proximity. The relative approach degree between the evaluation object and the positive ideal solution and the negative ideal solution is,

$$C_i = \frac{d_i^-}{d_i^+ + d_i^-} \tag{17}$$

According to the relative approach degree, the evaluation object is sorted.

4. Numerical experiment

In order to verify the reliability and validity of the method, we use the improved TOPSIS method to evaluate the supply chain risk of the fresh agricultural products in four different regions. We can get the weight of the evaluation index.

Table 2: Weight of index

Second order index	Weight	Third order index	Weight
Internal risk	0.32	Risk in choosing suppliers and dealers	0.12
		Quality risk of the fresh agricultural products	0.23
		Technical risk	0.15
		Risk of deterioration for the fresh agricultural products	0.23
		Risk management decision	0.17
		Quality of supply chain risk	0.05
		Structure of the supply chain risk	0.05
External risk	0.25	Credit risks	0.08
		Market environment risk	0.11
		Demand fluctuation risk	0.26
		Supply fluctuation risk	0.26
		Natural risk	0.10
		Policy risk	0.10
		Cooperation risk	0.09
Logistics risk	0.28	Transportation risk	0.33
		Distribution of risk	0.33
		Inventory risk	0.33
Information risk	0.15	Information transfer risk	0.5
		Information security risk	0.5

The distances between each index to the positive and the negative is,

$$d_1^+ = 0.0786, d_1^- = 0.1348, d_2^+ = 0.1211, d_2^- = 0.1105$$

$$d_3^+ = 0.1260, d_3^- = 0.1088, d_4^+ = 0.0971, d_4^- = 0.1301$$

The relative approach degree is,

$$C_1 = 0.6317, C_2 = 0.4772, C_3 = 0.4634, C_4 = 0.5726$$

Therefore, $C_1 > C_4 > C_2 > C_3$.

5. Conclusion

Because the particularity of the fresh agricultural products, it has the higher requirements of the supply chain. Therefore, the risk that the supply chain of the fresh agricultural products faces is higher than the general supply chain. Evaluating the supply chain risk of the fresh agricultural products can promote the manager transfers and avoids the risk process. The TOPSIS method depends on the expert opinion when solving the weight. Therefore, the evaluation result has the strong subjective and it is lack of the objectivity. This paper combines the improved entropy method and the TOPSIS method and proposes the improved TOPSIS method. Then, this paper uses the method to evaluate the supply chain risk of the fresh agricultural products. The evaluation results illustrate that the effectiveness of the evaluation system.

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