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Risk Assessment in the Supply Chain Management Based on Fuzzy AHP Model

LI Tao [a],*

[a] School of Business, East China University of Science and Technology, Shanghai 200237, P.R.China.

* Corresponding author.
Address: School of Business, East China University of Science and Technology, Shanghai 200237, P.R.China; E-Mail: golitao@163.com

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Abstract: In modern market economy, with the increasingly fierce business competition, supply chain management has become recognized as a business model. Each node enterprise in the supply chain must strengthen the supply chain risk management because of the management risk arising from supply chain management business model. Based on this, this paper provides scientific basis for supply chain risk management decisions with evaluating comprehensively supply chain management risk from whole to part and making an empirical analysis.

Key words: Supply chain; Supply chain management; Fuzzy AHP model; Risk assessment

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1. INTRODUCTION

Enterprise can achieve the expected target by improving the overall operation of the supply chain level, and also can make the supply chain operate in designed state by assessing and then reducing supply chain management risk. This paper makes a quantitative research in the perspective of supply chain management risk [1].

2. PROCESS OF SUPPLY CHAIN RISK MANAGEMENT

Firstly, Supply chain managers must be able to identify risk in the process of supply chain management through anglicizing the whole process of supply chain management, and then systematically classify and identify the existed and potential risks using various methods [2]. Secondly, we need to identify the factors of identified existed and potential risks and assess the risk tolerance of each node enterprise in the supply chain. For the second time, we need to develop and operate the practicable measures according to supply chain management objectives. Finally, we must monitor the process of implementation ensuring supply chain run in accordance with established goals, meanwhile adjust the supply chain operation under both external and internal environment changes [3,4].

3. COMPREHENSIVE EVALUATION MODEL WITH FUZZY AHP

Separately make a comprehensive evaluation of suppliers, manufacturers, vendors in each node in supply chain, and then design a supply chain management risk index system [5–7].

Table 1
Supply Chain Management Risk Index System

Supply Chain Management Risk Index U													
Operation Risk U_1				**Finance Rish** U_2			**Technology Risk** U_3				**Market Rish** U_4		
X_{11}	X_{12}	X_{13}	X_{14}	X_{21}	X_{22}	X_{23}	X_{31}	X_{32}	X_{33}	X_{34}	X_{41}	X_{42}	X_{43}

X_{11} – marketing risk, X_{12} – collaboration risk, X_{13} – supply risk, X_{14} – product risk, X_{21} – current liabilities, X_{22} – assets liabilities, X_{23} – equity ratio, X_{31} – production technology, X_{32} – inventory technology, X_{33} – transportation technology, X_{34} – information technology, X_{41} – demand risk, X_{42} – price risk, X_{43} – competition risk.

According to the evaluation index system, we can establish analysis model with fuzzy comprehensive evaluation method.

Suppose factor set $U = \{ \ U_1 \quad U_2 \quad U_3 \quad U_4 \ \}$,

$$U_1 = \{ \ X_{11} \quad X_{12} \quad X_{13} \quad X_{14} \ \}, U_2 = \{ \ X_{21} \quad X_{22} \quad X_{23} \ \}$$
$$U_3 = \{ \ X_{31} \quad X_{32} \quad X_{33} \quad X_{34} \ \}, U_4 = \{ \ X_{41} \quad X_{42} \quad X_{43} \ \}$$

Suppose reviews set $V = \{ \ Y_1 \quad Y_2 \quad Y_3 \quad Y_4 \quad Y_5 \ \}$,

Y_1 – Higher risk, Y_2 – high risk, Y_3 – General risk, Y_4 – Low risk, Y_5 – less risk.

Comprehensively evaluate each $U_i (i = 1, 2, 3, 4)$.

Because we cant obtain all the quantitative data of index X_{ij} , we need to judge the degree index r_{ij} describing the degree of X_{ij} belonging to Y according to reviews set V with Delphi method or random survey.

$$R_1 = \begin{bmatrix} r_{111} & r_{112} & r_{113} & r_{114} & r_{115} \\ r_{121} & r_{122} & r_{123} & r_{124} & r_{125} \\ r_{131} & r_{132} & r_{133} & r_{134} & r_{135} \\ r_{141} & r_{142} & r_{143} & r_{144} & r_{145} \end{bmatrix}, R_2 = \begin{bmatrix} r_{211} & r_{212} & r_{213} & r_{214} & r_{215} \\ r_{221} & r_{222} & r_{223} & r_{224} & r_{225} \\ r_{231} & r_{232} & r_{232} & r_{234} & r_{235} \end{bmatrix},$$

$$R_3 = \begin{bmatrix} r_{311} & r_{312} & r_{313} & r_{314} & r_{315} \\ r_{321} & r_{322} & r_{323} & r_{324} & r_{325} \\ r_{331} & r_{332} & r_{333} & r_{334} & r_{335} \\ r_{341} & r_{342} & r_{343} & r_{344} & r_{345} \end{bmatrix}, R_4 = \begin{bmatrix} r_{411} & r_{412} & r_{413} & r_{414} & r_{415} \\ r_{421} & r_{422} & r_{423} & r_{424} & r_{425} \\ r_{431} & r_{432} & r_{432} & r_{434} & r_{435} \end{bmatrix}.$$

Establish judgment matrix with AHP method and then solve the matrix. Firstly, we need to solve the largest eigenvalue $\lambda_{\max}$ and eigenvector $Z = \begin{bmatrix} Z_1 & Z_2 & \cdots & Z_4 \end{bmatrix}^T$. Secondly, normalize the eigenvector,

$$W_i = \frac{Z_i}{\sum_{j=1}^{n} Z_i}, W = \begin{bmatrix} W_1 & W_2 & \cdots & W_4 \end{bmatrix}^T$$

$CI = \frac{\lambda_{\max} - n}{n-1}$, RI is the index value to judge average random consistency of a matrix.

If $CR = \frac{CI}{RI} < 0.01$, we can include that judgment matrix has satisfactory consistency ratio. Finally, we can obtain comprehensive evaluation model by synthesis operations of fuzzy matrix, and then make a overall assessment based on supply chain management risk.

4. EMULATION ANALYSIS

According to the comprehensive assessment on a company's supply chain management risk with supply chain risk index and reviews set, we can obtain fuzzy judgment matrix.

$$R_1 = \begin{bmatrix} 0.28 & 0.14 & 0.25 & 0.2 & 0.13 \\ 0.25 & 0.16 & 0.24 & 0.21 & 0.14 \\ 0.26 & 0.18 & 0.23 & 0.22 & 0.11 \\ 0.23 & 0.16 & 0.28 & 0.24 & 0.09 \end{bmatrix}, R_2 = \begin{bmatrix} 0.17 & 0.2 & 0.22 & 0.24 & 0.17 \\ 0.2 & 0.18 & 0.3 & 0.2 & 0.12 \\ 0.22 & 0.17 & 0.2 & 0.32 & 0.09 \end{bmatrix},$$

$$R_3 = \begin{bmatrix} 0.13 & 0.21 & 0.3 & 0.04 & 0.32 \\ 0.2 & 0.16 & 0.15 & 0.22 & 0.27 \\ 0.25 & 0.23 & 0.17 & 0.11 & 0.24 \\ 0.19 & 0.21 & 0.24 & 0.06 & 0.3 \end{bmatrix}, R_4 = \begin{bmatrix} 0.17 & 0.2 & 0.31 & 0.24 & 0.08 \\ 0.21 & 0.15 & 0.25 & 0.3 & 0.09 \\ 0.3 & 0.15 & 0.17 & 0.23 & 0.15 \end{bmatrix}.$$

Test the consistency of judgment matrix with APH.

$$C = \begin{bmatrix} 1 & 5 & 7 & 3 \\ 1/5 & 1 & 4 & 1/2 \\ 1/7 & 1/4 & 1 & 1/4 \\ 1/3 & 1/3 & 4 & 1 \end{bmatrix}, W = \begin{bmatrix} 0.573 \\ 0.145 \\ 0.056 \\ 0.226 \end{bmatrix},$$

$$\lambda_{\max} = 4.012, CI = 0.004, RI = 0.9, CR = 0.0044;$$

$$C_1 = \begin{bmatrix} 1 & 3 & 6 & 5 \\ 1/3 & 1 & 2 & 3 \\ 1/6 & 1/2 & 1 & 1/2 \\ 1/5 & 1/3 & 2 & 1 \end{bmatrix}, W = \begin{bmatrix} 0.57 \\ 0.228 \\ 0.086 \\ 0.116 \end{bmatrix},$$

$$\lambda_{\max} = 4.0116, CI = 0.038, RI = 0.9, CR = 0.0422;$$

$$C_2 = \begin{bmatrix} 1 & 1 & 2 \\ 1 & 1 & 2 \\ 1/2 & 1/2 & 1 \end{bmatrix}, W = \begin{bmatrix} 0.4 \\ 0.4 \\ 0.2 \end{bmatrix},$$

$$\lambda_{\max} = 3, CI = 0, RI = 0.58, CR = 0;$$

$$C_3 = \begin{bmatrix} 1 & 3 & 3 & 7 \\ 1/3 & 1 & 1 & 5 \\ 1/3 & 1 & 1 & 3 \\ 1/7 & 1/5 & 1/3 & 1 \end{bmatrix}, W = \begin{bmatrix} 0.534 \\ 0.218 \\ 0.188 \\ 0.06 \end{bmatrix},$$

$$\lambda_{\max} = 4.057, CI = 0.019, RI = 0.9, CR = 0.021;$$

$$C_4 = \begin{bmatrix} 1 & 1/5 & 1/2 \\ 5 & 1 & 3 \\ 2 & 1/3 & 1 \end{bmatrix}, W = \begin{bmatrix} 0.122 \\ 0.648 \\ 0.23 \end{bmatrix},$$

$$\lambda_{\max} = 3.004, CI = 0.002, RI = 0.58, CR = 0.0034.$$

$$R = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{bmatrix} = \begin{bmatrix} 0.265 & 0.15 & 0.25 & 0.209 & 0.126 \\ 0.192 & 0.186 & 0.248 & 0.24 & 0.134 \\ 0.17 & 0.202 & 0.239 & 0.096 & 0.293 \\ 0.226 & 0.156 & 0.239 & 0.276 & 0.103 \end{bmatrix}$$

Through calculation above, we can obtain weight vector of X layer compared to U layer:

$$N_1 = \begin{bmatrix} 0.57 & 0.228 & 0.086 & 0.116 \end{bmatrix}, N_2 = \begin{bmatrix} 0.4 & 0.4 & 0.2 \end{bmatrix},$$

$$N_3 = \begin{bmatrix} 0.534 & 0.218 & 0.188 & 0.06 \end{bmatrix}, N_4 = \begin{bmatrix} 0.122 & 0.648 & 0.23 \end{bmatrix}.$$

Obtain weight vector of U layer compared to A layer:

$$N = \begin{bmatrix} 0.573 & 0.145 & 0.056 & 0.226 \end{bmatrix},$$

$$B_1 = N_1 * R_1 = \begin{bmatrix} 0.265 & 0.15 & 0.25 & 0.209 & 0.126 \end{bmatrix},$$

$$B_2 = N_2 * R_2 = \begin{bmatrix} 0.192 & 0.186 & 0.248 & 0.24 & 0.134 \end{bmatrix},$$

$$B_3 = N_3 * R_3 = \begin{bmatrix} 0.17 & 0.202 & 0.239 & 0.096 & 0.293 \end{bmatrix},$$

$$B_4 = N_4 * R_4 = \begin{bmatrix} 0.226 & 0.156 & 0.239 & 0.276 & 0.103 \end{bmatrix},$$

$$B = N * R = \begin{bmatrix} 0.24 & 0.16 & 0.246 & 0.223 & 0.131 \end{bmatrix}.$$

Give corresponding marks according to the five levels divided into by reviews set: $F = (10, 8, 6, 4, 2)$. And then we can obtain the total score of this supply chain:

$$0.24 * 10 + 0.16 * 8 + 0.246 * 6 + 0.223 * 4 + 0.131 * 2 = 6.35 > 0.5.$$

So we can include that this supply chain has higher risk. Similarly, we can obtain the total score of this supply chain in respective of suppliers, manufacturers or vendors:

Suppliers: $B = \begin{bmatrix} 0.26 & 0.18 & 0.23 & 0.228 & 0.102 \end{bmatrix}$, total score is 6.536;

Manufacturers: $B = \begin{bmatrix} 0.23 & 0.12 & 0.31 & 0.22 & 0.12 \end{bmatrix}$, total score is 6.24;

Vendors: $B = \begin{bmatrix} 0.227 & 0.162 & 0.265 & 0.21 & 0.136 \end{bmatrix}$, total score is 6.268.

5. CONCLUSION

By comparing the size of the total score, we can find that the management risk arising from suppliers is the highest. So this company should firstly strengthen the integrated management of suppliers to reduce the risk of supply chain management.

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