Research on Supply Chain Risk Evaluation of Furniture Manufacturing Industry

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Abstract: With the rapid development of furniture manufacturing industry, the research of supply chain risk evaluation is more and more concerned by the industry. How to evaluate supply chain risk is the focus of current research. In this paper, SCOR model is used to identify supply chain risk factors of furniture manufacturing industry from five aspects: planning, procurement, production, distribution and returns, and the supply chain risk evaluation index system is constructed. The analytic hierarchy process (AHP) is used to determine the risk index weight, and the fuzzy comprehensive evaluation is used to comprehensively evaluate the supply chain risk, and risk coping strategies with suggestions are proposed according to the evaluation results.

Keywords: Furniture Manufacturing Supply Chain; SCOR Model; Risk Evaluation; Fuzzy Comprehensive Evaluation

1. Introduction

At present, research on supply chain risk evaluation has become a key direction of supply chain risk management [1,2], and efficient risk evaluation methods are a prerequisite for proposing efficient risk management strategies. Currently, there are relatively few research results on supply chain risks in the furniture manufacturing industry both domestically and internationally, mainly focusing on qualitative analysis, with a lack of research on quantitative analysis. This article constructs a supply chain risk evaluation index system for the furniture manufacturing industry based on relevant literature research results. Fuzzy comprehensive evaluation is used to quantitatively analyze the supply chain risk index of the furniture manufacturing industry, and risk response strategies are proposed based on the comprehensive evaluation results.

2. Identification and Analysis of Supply Chain Risk Factors

The furniture manufacturing industry mainly includes a series of links such as procurement, production, logistics, distribution, and after-sales service. While its supply chain is complex and diverse, it also comes with more risks. Therefore, it is very important to systematically identify the supply chain risks of the furniture manufacturing industry. This article analyzes the specific actual situation of the furniture manufacturing supply chain, based on the SCOR model [3], and identifies the supply chain risks of the furniture manufacturing industry from the perspective of the supply chain operation process. It analyzes the supply chain risks of the furniture manufacturing industry from five aspects: planning, procurement, production, distribution, and return.

2.1 Planning Risk

In the planning process, inaccurate market demand forecasting by enterprises often leads to overcapacity or insufficient production capacity, which directly affects inventory levels; Unreasonable production schedule arrangements can cause delays in production progress; Reasonable resource allocation is the key to improving efficiency. Improper allocation of production resources can easily lead to a decrease in total factor productivity, disrupt industrial production development [4], and increase production costs.

2.2 Procurement Risk

In the procurement process, it is very important for enterprises to choose stable and reliable suppliers. Supplier selection is a complex but strategic decision that is influenced by many factors [5]. Improper supplier selection by enterprises will lead to a decrease in product production quality and progress, affecting the stability of the entire supply chain; With the rise of prices, the increase in procurement prices will lead to an increase in production costs, and the profit margin of enterprises will further shrink; When the procurement quantity does not match the demand, it often leads to inventory backlog or shortage of goods.

2.3 Production Risk

In the production process, workers are the key core of production, and furniture production is a specific industrial sector with high labor demand and a wide variety of processing types [6]. If the level of specialization of workers is not high, it will lead to insufficient product quality, resulting in a reduction in the consumer group of the enterprise; Stable and reliable production equipment and the prevention of production safety accidents are prerequisites for ensuring normal production. Equipment failures and production safety accidents can cause production stagnation and losses, and even lead to supply chain disruptions.

2.4 Distribution Risk

In the distribution process, distribution costs, distribution speed and distribution of goods intact delivery is the focus of the enterprise distribution process considerations, distribution costs will increase the compression of corporate profit margins, logistics and distribution delays and distribution of damaged goods will seriously affect the enterprise's reputation and reputation.

2.5 Return Risk

In the return process, when a company encounters product quality issues, poor customer service attitude, or a long return business process, it is easy to lead to customer dissatisfaction and customer loss.

3. Construction and Evaluation of Supply Chain Risk Index System

3.1 Construction of Supply Chain Risk Evaluation Index System

Based on the SCOR model, an analysis of supply chain risks in the furniture manufacturing industry was conducted. Fifteen risk factors were subdivided into five processes: planning, procurement, production, distribution, and return, and their hierarchical structure was determined. Based on this, a supply chain risk evaluation index system for the furniture manufacturing industry was constructed, as shown in Table 1.

Table 1. Furniture Manufacturing Supply Chain Risk Evaluation Index System A

	Primary Index	Secondary Index
Furniture manufacturing supply chain risk evaluation index system A	Planning risk U_1	Inaccurate forecasting of market demand U_{11} Inadequate scheduling of production U_{12} Misallocation of productive resources U_{13}
	Procurement risk U_2	Inadequate selection of vendors U_{21} Higher procurement prices U_{22} Mismatch between quantity procured and requirements U_{23}
	Production risk U_3	Low level of worker specialization U_{31} Failure of production equipment U_{32} accident occurring due to production safety U_{33}
	Distribution risk U_4	Higher distribution costs U_{41} Delays in logistics and distribution U_{42} Distribution of damaged goods U_{43}
	Return risk U_5	Product quality issues U_{51} Poor customer service U_{52} Excessively long return business processes U_{53}

3.2 Supply Chain Risk Evaluation

In this paper, the data sources are distributed to relevant managers with practical experience in the furniture manufacturing industry or in the industry through questionnaires to obtain data, and the obtained data is effectively extracted, the hierarchical analysis [7,8] is used to determine the weight of risk index, and the quantitative representation is carried out through fuzzy comprehensive evaluation [9], so as to obtain the risk evaluation results.

3.2.1 Determine the supply chain risk factor set U of furniture manufacturing industry

According to Table 1. supply chain risk evaluation index system of furniture manufacturing industry, the supply chain risk of furniture manufacturing industry is specifically divided into primary index $U=\{U_1,U_2,U_3,U_4,U_5\}$, and secondary index $U_{ij}=\{U_{11}, U_{12}, U_{13}, U_{23}... U_{53}\}$.

3.2.2 Determine furniture manufacturing supply chain risk assessment set V

The risk was divided into five levels, namely "highest risk, high risk, medium risk, low risk, Minimum risk". The set of risk ratings is set as $V=\{V_1,V_2,V_3,V_4,V_5\}$, and the corresponding values are {10,8,6,4,2}, and the higher the ratings, the higher the risk.

3.2.3 Determination of supply chain risk index weight

(1) Construct the judgment matrix and consistency test of pairwise comparison

Based on the establishment of primary and secondary indexes, this paper uses the 1-9 scale method [10] to assign values, and constructs the hierarchical judgment matrix, as shown in Table 2.

Table 2. First Level Judgement Matrix A

	Expert 1					Expert 2					Expert 3				
A	U_1	U_2	U_3	U_4	U_5	U_1	U_2	U_3	U_4	U_5	U_1	U_2	U_3	U_4	U_5
U_1	1	3	6	9	7	1	1/5	3	5	7	1	3	1/3	6	5
U_2	1/3	1	3	6	5	5	1	5	7	9	1/3	1	1/5	5	3
U_3	1/6	1/3	1	5	2	1/3	1/5	1	3	5	3	5	1	9	6
U_4	1/9	1/6	1/5	1	1/3	1/5	1/7	1/3	1	3	1/6	1/5	1/9	1	1/3
U_5	1/7	1/5	1/2	3	1	1/7	1/9	1/5	1/3	1	1/5	1/3	1/6	3	1
	Expert 4					Expert 5									
A	U_1	U_2	U_3	U_4	U_5	U_1	U_2	U_3	U_4	U_5					
U_1	1	6	2	5	8	1	7	3	5	9					
U_2	1/6	1	1/5	1/3	3	1/7	1	1/5	1/3	3					
U_3	1/2	5	1	3	5	1/3	5	1	2	5					
U_4	1/5	3	1/3	1	5	1/5	3	1/2	1	6					
U_5	1/8	1/3	1/5	1/5	1	1/9	1/3	1/5	1/6	1					

In order to ensure the logical rationality of the index judgment, it is necessary to carry out the consistency test on the determined judgment matrix. The formula is:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (1)$$

Where CI is the consistency index, λ_{max} is the largest eigenroot of the matrix, and n is the order of the matrix.

When the consistency index CI is found, the corresponding average random consistency index RI is found according to the matrix order, and the consistency ratio CR is calculated, and the consistency test is passed when the consistency ratio CR<0.1. The formula is:

$$CR = \frac{CI}{RI} \quad (2)$$

This paper calculates the eigenvector and maximum eigenroot of the judgment matrix by sum-product method, and then calculates the consistency test results of the judgment matrix of five experts by formula (1) and formula (2) as $CR_{A(1)}=0.0503$, $CR_{A(2)}=0.0831$, $CR_{A(3)}=0.0593$, $CR_{A(4)}=0.0585$, $CR_{A(5)}=0.0539$, whose consistency ratio CR is less than 0.1, all pass the consistency test, and then the group decision judgment matrix is obtained by summarizing and processing them by geometric average method, as shown in Table 3.

Table 3. Hierarchy A Group Decision Making Judgment Matrix

A	U_1	U_2	U_3	U_4	U_5
U_1	1	2.3752	2.0477	5.8326	7.0681
U_2	0.4210	1	0.6544	1.8776	4.1392
U_3	0.4884	1.5281	1	3.8186	4.3174
U_4	0.1715	0.5326	0.2620	1	1.5849
U_5	0.1415	0.2416	0.2316	0.6310	1

Finally, the consistency test of the group decision judgement matrix of layer A was carried out again, and it was calculated that $\lambda_{max}=5.0370$, CI=0.0092, CR=0.0082<0.1, which indicated that the group decision judgement matrix passed the consistency test, and to determine its level of index weight $\{U_1, U_2, U_3, U_4, U_5\}$ = {0.438, 0.179, 0.251, 0.079, 0.053}. The results of each judgment matrix of the second layer are summarized and calculated below according to the above method, which will not be repeated later, and the judgment matrices of each group decision of the second layer are shown in Table 4, Table 5, Table 6, Table 7, and Table 8.

Table 4. U_1 Hierarchical Group Decision Judgment Matrix Table

U_1	U_{11}	U_{12}	U_{13}
U_{11}	1	0.6310	0.7277
U_{12}	1.5849	1	1.4532
U_{13}	1.3742	0.6881	1

Table 5. U_2 Hierarchical Group Decision Judgment Matrix Table

U_2	U_{21}	U_{22}	U_{23}
U_{21}	1	3.7279	6.7595
U_{22}	0.2682	1	1.4758
U_{23}	0.1479	0.6776	1

Table 6. U_3 Hierarchical Group Decision Judgment Matrix Table

U_3	U_{31}	U_{32}	U_{33}
U_{31}	1	0.298	0.1655
U_{32}	3.3470	1	0.4152
U_{33}	6.0438	2.4082	1

Table 7. U_4 Hierarchical Group Decision Judgment Matrix Table

U_4	U_{41}	U_{42}	U_{43}
U_{41}	1	3.7279	6.3196
U_{42}	0.2682	1	1.4758
U_{43}	0.1582	0.6776	1

Table 8. U_5hierarchical Group Decision Judgment Matrix Table

U_5	U_{51}	U_{52}	U_{53}
U_{51}	1	3.6297	5.5780
U_{52}	0.2755	1	1.6004
U_{53}	0.1793	0.6248	1

Finally calculated the second layer of judgment matrix $\{CR_{U1}, CR_{U2}, CR_{U3}, CR_{U4}, CR_{U5}\} = \{0.0057, 0.0044, 0.0090, 0.0019, 0.0002\}$, all through the consistency check, and to determine the index weight.

(2) Construct the weight table of supply chain risk index

The risk index are solved by the above data to produce a table of supply chain risk indicator weights for the furniture manufacturing industry, as shown in Table 9.

Table 9. Weight Table of Supply Chain Risk Index of Furniture Manufacturing Industry

	Primary index	weight	Secondary index	weight	Comprehensive weight
Furniture manufacturing supply chain risk evaluation index system A	Planning risk U_1	0.438	Inaccurate forecasting of market demand U_{11} Inadequate scheduling of production U_{12} Misallocation of productive resources U_{13}	0.251 0.430 0.319	0.109938 0.18834 0.139722
	Procurement risk U_2	0.179	Inadequate selection of vendors U_{21} Higher procurement prices U_{22} Mismatch between quantity procured and requirements U_{23}	0.709 0.178 0.113	0.126911 0.031862 0.020227
	Production risk U_3	0.251	Low level of worker specialization U_{31} Failure of production equipment U_{32} accident occurring due to production safety U_{33}	0.094 0.285 0.621	0.023594 0.071535 0.155871
	Distribution risk U_4	0.079	Higher distribution costs U_{41} Delays in logistics and distribution U_{42} Distribution of damaged goods U_{43}	0.703 0.180 0.117	0.055537 0.01422 0.009243
	Return risk U_5	0.053	Product quality issues U_{51} Poor customer service U_{52} Excessively long return business processes U_{53}	0.687 0.192 0.121	0.036411 0.010176 0.006413

3.2.4 Fuzzy comprehensive evaluation of supply chain risk

Based on the fuzzy evaluation theory, a questionnaire survey was designed according to five risk rating levels, the scoring data of senior personnel in the furniture manufacturing industry on the risk of their secondary index were collected, sorted out and analyzed, and the corresponding risk evaluation matrix was established.

(1) Determine the membership matrix of fuzzy relation

Through data processing, the membership matrix of five aspects of risk in the supply chain, namely planning, procurement, production, distribution and return, is established respectively, and expressed in terms of R1, R2, R3, R4, R5:

$$R_1=\begin{vmatrix} 0.1 & 0.2 & 0.4 & 0.2 & 0.1 \\ 0.2 & 0.5 & 0.2 & 0.1 & 0 \\ 0.2 & 0.4 & 0.1 & 0.1 & 0.2 \end{vmatrix}$$

$$R_2=\begin{vmatrix} 0.4 & 0.3 & 0.1 & 0.2 & 0 \\ 0.5 & 0.2 & 0.1 & 0.1 & 0.1 \\ 0.1 & 0.1 & 0.3 & 0.2 & 0.3 \end{vmatrix}$$

$$R_3=\begin{vmatrix} 0.1 & 0.1 & 0.4 & 0.1 & 0.3 \\ 0.3 & 0.2 & 0.3 & 0.1 & 0.1 \\ 0.6 & 0.2 & 0.1 & 0.1 & 0 \end{vmatrix}$$

$$R_4=\begin{bmatrix}0.5 & 0.3 & 0.1 & 0.1 & 0\\0.1 & 0.3 & 0.2 & 0.3 & 0.1\\0.2 & 0.3 & 0.2 & 0.2 & 0.1\end{bmatrix}$$

$$R_5=\begin{bmatrix}0.3 & 0.5 & 0.1 & 0.1 & 0\\0.1 & 0.3 & 0.3 & 0.1 & 0.2\\0.2 & 0.3 & 0.3 & 0.1 & 0.1\end{bmatrix}$$

(2) Comprehensively evaluate the supply chain risks of furniture manufacturing industry

In order to evaluate supply chain risk comprehensively, the comprehensive membership vector B_i should be calculated. The formula is:

$$B_i = W_i \cdot R_i \tag{3}$$

Where W_i is the weight of the corresponding Secondary index under each Primary index, according to Table 9. The calculation process according to formula (3) is as follows:

$B_1=W_1 \cdot R_1=$

$$\begin{bmatrix}0.251 & 0.430 & 0.319\end{bmatrix}\begin{bmatrix}0.1 & 0.2 & 0.4 & 0.2 & 0.1\\0.2 & 0.5 & 0.2 & 0.1 & 0\\0.2 & 0.4 & 0.1 & 0.1 & 0.2\end{bmatrix}$$

$=\begin{bmatrix}0.1749 & 0.3928 & 0.2183 & 0.1251 & 0.0889\end{bmatrix}$

$B_2=W_2 \cdot R_2=$

$$\begin{bmatrix}0.709 & 0.178 & 0.113\end{bmatrix}\begin{bmatrix}0.4 & 0.3 & 0.1 & 0.2 & 0\\0.5 & 0.2 & 0.1 & 0.1 & 0.1\\0.1 & 0.1 & 0.3 & 0.2 & 0.3\end{bmatrix}$$

$=\begin{bmatrix}0.3839 & 0.2596 & 0.1226 & 0.1822 & 0.0517\end{bmatrix}$

$B_3=W_3 \cdot R_3=$

$$\begin{bmatrix}0.094 & 0.285 & 0.621\end{bmatrix}\begin{bmatrix}0.1 & 0.1 & 0.4 & 0.1 & 0.3\\0.3 & 0.2 & 0.3 & 0.1 & 0.1\\0.6 & 0.2 & 0.1 & 0.1 & 0\end{bmatrix}$$

$=\begin{bmatrix}0.4675 & 0.1906 & 0.1852 & 0.1000 & 0.0567\end{bmatrix}$

$B_4=W_4 \cdot R_4=$

$$\begin{bmatrix}0.703 & 0.180 & 0.117\end{bmatrix}\begin{bmatrix}0.5 & 0.3 & 0.1 & 0.1 & 0\\0.1 & 0.3 & 0.2 & 0.3 & 0.1\\0.2 & 0.3 & 0.2 & 0.2 & 0.1\end{bmatrix}$$

$=\begin{bmatrix}0.3929 & 0.3000 & 0.1297 & 0.1477 & 0.0297\end{bmatrix}$

$B_5=W_5 \cdot R_5=$

$$\begin{bmatrix}0.687 & 0.192 & 0.121\end{bmatrix}\begin{bmatrix}0.3 & 0.5 & 0.1 & 0.1 & 0\\0.1 & 0.3 & 0.3 & 0.1 & 0.2\\0.2 & 0.3 & 0.3 & 0.1 & 0.1\end{bmatrix}$$

$=$

$\begin{bmatrix}0.2495 & 0.4374 & 0.1626 & 0.1000 & 0.0505\end{bmatrix}$

Based on the above comprehensive membership degree vector, the overall comprehensive membership degree direction of the supply chain risk of the furniture manufacturing industry can be calculated as follows.

$B_{Total} = W_{Total} \cdot R_{Total}$ (W_{Total} is the weight of each level of indicator)

$$=\begin{bmatrix}0.438 & 0.179 & 0.251 & 0.079 & 0.053\end{bmatrix}\begin{bmatrix}0.1749 & 0.3928 & 0.2183 & 0.1251 & 0.0889\\0.3839 & 0.2596 & 0.1226 & 0.1822 & 0.0517\\0.4675 & 0.1906 & 0.1852 & 0.1000 & 0.0567\\0.3929 & 0.3000 & 0.1297 & 0.1477 & 0.0297\\0.2495 & 0.4374 & 0.1626 & 0.1000 & 0.0505\end{bmatrix}$$

$$=\begin{bmatrix}0.3069 & 0.3132 & 0.1829 & 0.1295 & 0.0674\end{bmatrix}$$

On the basis of obtaining the comprehensive membership degree vector, the comprehensive score of risk index is calculated according to the evaluation formula of risk index. The formula is:

$$F_i = B_i \cdot V \tag{4}$$

The calculation process according to formula (4) is as follows:

$F_1=B_1 \cdot V=$

$$\begin{bmatrix}0.1749 & 0.3928 & 0.2183 & 0.1251 & 0.0889\end{bmatrix}\begin{bmatrix}10\\8\\6\\4\\2\end{bmatrix}$$

$=6.88$

$F_2=B_2 \cdot V=$

$$\begin{bmatrix}0.3839 & 0.2596 & 0.1226 & 0.1822 & 0.0517\end{bmatrix}\begin{bmatrix}10\\8\\6\\4\\2\end{bmatrix}$$

$=7.48$

$F_3=B_3 \cdot V=$

$$\begin{bmatrix}0.4675 & 0.1906 & 0.1852 & 0.1000 & 0.0567\end{bmatrix}\begin{bmatrix}10\\8\\6\\4\\2\end{bmatrix}$$

$=7.82$

$F_4=B_4 \cdot V=$

$$\begin{bmatrix}0.3929 & 0.3000 & 0.1297 & 0.1477 & 0.0297\end{bmatrix}\begin{bmatrix}10\\8\\6\\4\\2\end{bmatrix}$$

$=7.76$

$F_5=B_5 \cdot V=$

$$\begin{bmatrix}0.2495 & 0.4374 & 0.1626 & 0.1000 & 0.0505\end{bmatrix}\begin{bmatrix}10\\8\\6\\4\\2\end{bmatrix}$$

$=7.47$

The overall comprehensive score of supply chain risk of furniture manufacturing industry is:

$F_{Total} = B_{Total} \cdot V$

$=$

$$[0.3069 \quad 0.3132 \quad 0.1829 \quad 0.1295 \quad 0.0674]\begin{bmatrix}10\\8\\6\\4\\2\end{bmatrix}$$

=7.32

According to the appeal calculation results, combined with the maximum membership degree rule, the final comprehensive evaluation results of five risk index such as "planning, procurement, production, distribution and return" are respectively "high risk, Highest risk, Highest risk, Highest risk, high risk", and the overall comprehensive evaluation result of the supply chain risk of the furniture manufacturing industry is high risk. According to the comprehensive score of each risk factor, except for the planned risk, which is between 6 and 7, the scores of other risks are all higher than 7 points, all of which are close to the high risk level, and the risk factors are ranked from the highest to the lowest in terms of score value: production > distribution > procurement > return > planning. Finally, the overall comprehensive score of the supply chain risk of the furniture manufacturing industry is 7.32 points. Its supply chain risks are high.

4. Conclusion

In this paper, SCOR model is adopted to identify the supply chain risk of furniture manufacturing industry, and a supply chain risk evaluation model suitable for furniture manufacturing industry is constructed by AHP and fuzzy comprehensive evaluation. Finally, it can be seen from the risk evaluation results that there are high risks in the supply chain of furniture manufacturing industry, especially in the three Primary index risks of procurement, production and distribution. It is necessary to focus on three secondary index risks, such as improper supplier selection, production safety accidents and increased distribution costs. In order to prevent and control the supply chain risk, the following suggestions are put forward:

Furniture manufacturing industry is mainly involved in the procurement of wood, through the establishment of diversified procurement channels, to avoid over-reliance on fixed procurement channels, to ensure the timely supply of wood and sufficient quantity, the use of flexible procurement methods in a timely manner to adjust and replace unstable and reliable procurement channels. In the selection of suppliers, the quality of their products, delivery ability, price and reputation should be comprehensively investigated and evaluated to ensure the stability and reliability of suppliers, while establishing clear contract terms, clear responsibilities and obligations of suppliers, reduce procurement risks.

Through the introduction of advanced furniture production technology and high-quality production equipment, reduce the production failure rate, and promote the improvement of production efficiency and product quality. Regularly conduct furniture production skills training and skill assessment for employees to improve the professional level. Shape the safety production culture of the enterprise, and at the same time regularly inspect the production site, check and rectify the possible safety hazards in time, and reduce the occurrence of production safety accidents.

Furniture manufacturing logistics distribution is mainly for large products, need to choose a reliable logistics company to ensure that the distribution of goods damage rate is reduced, you can sign long-term contracts, establish long-term cooperation, in order to reduce distribution costs. Logistics distribution of furniture manufacturing industry is usually less cross-regional distribution, enterprises can also choose self-distribution, joint distribution or third-party logistics distribution according to the actual situation to reduce distribution costs and ensure the stability of the supply chain.

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