Study On Risk Identification of Corporate Supply Chain Finance Based on ISM-MICMAC Model

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Abstract. It is crucial to accurately identify the main influencing factors of supply chain finance risk, analyze their mechanism of action and construct a system of influencing factors for risk management of supply chain finance. This paper examines the three parties involved in supply chain finance, including the financial institution, the core enterprise, and the SMEs, and screens out 21 major risk factors from them. This study calculates the adjacency matrix and accessibility matrix by using SPSSPRO, then constructs the interpretative structural modeling method (ISM) and the recursive structure diagram. Combining the Matrix-based Multiplication Applied to a Classification (MICM), this paper classifies the influencing factors into four categories: autonomous category, dependent category, linkages category, and independent category. The results show that: (1) the factors that constitute the deepest level of risk in supply chain finance are crediting false trade, non-standard bill of lading, data information security risk, imperfection of business process design, et cetera. (2) Among all factors, three factors are identified as the autonomous category, nine as the independent category, and nine as the dependent category with no linkages category.

Keywords: Risk Identification of Supply Chain Finance, ISM-MICMAC Model, Risk Factors.

1. Introduction

With the deepening of the socialized production method, the service targets of the financial industry have changed from individuals and enterprises to all participants in the whole supply chain. Accordingly, traditional finance has gradually developed in the direction of supply chain finance. However, supply chain finance also faces risks such as default and funding chain rupture, so it is essential to carry out risk management. The identification of supply chain finance risks is the basis for implementing risk management. A systematic approach is used to analyze possible types of risks and potential causes before they arise.

Numerous studies have been conducted by scholars on default risk:
Risk identification of supply chain finance mainly includes identifying risk elements and the differentiation of risky firms. Tian et al. [1] constructed SMEs’ credit risk assessment model through factor analysis and logistic regression. Li et al. [2] used the rooting theory approach to demonstrate that environmental, network, and management factors can constitute the induced factor model of supply chain finance risk. For the differentiation of risky enterprises, many scholars have primarily conducted research from the perspective of machine learning. Sun et al. [3] used GA-BP neural network algorithm to construct a model of an agricultural risk evaluation index system of supply chain finance. They used the case study method, and the results showed improved risk prediction efficiency and accuracy. Zhang et al. [4] used FA-SVM to evaluate the default risk of supply chain finance. They confirmed that it could improve the accuracy of risky enterprise classification and identification.

Previous studies have analyzed and explored the risk identification of supply chain finance, which has significantly contributed to the related discipline. However, considering that the subjects involved in supply chain finance include the financial institution, the core enterprise, and the SMEs, most of the studies on risk identification of supply chain finance have focused on the risk indicators of one or two subjects, but lacked the study of all the influencing factors of the three subjects. Therefore, this paper intends to use the system engineering theoretical approach to systematically identify the risks among the three subjects based on ISM-MICMAC, study the factor contagion paths, and classify the factors. The research in this paper facilitates the identification and reduction of possible risks faced
by the subjects concerned with the supply chain and provides a methodology for analyzing the relationship between various risk factors and formulating effective risk prevention measures.

2. Risk Identification of Corporate Supply Chain Finance

2.1 The Financial Institution

The financial institution is the leading provider of funds and risk taker in supply chain finance, mainly responsible for providing financing services to the core and SMEs to solve the liquidity problems for these enterprises. The risks of the financial institution include uncollectible accounts receivable ($A_1$), crediting false trade ($A_2$), frustration of the pledge right ($A_3$), non-standard bill of lading ($A_4$), operational process violations ($A_5$), international business disputes ($A_6$) and the unreasonable use of financial technology ($A_7$).

2.2 The Core Enterprise

The core enterprise is the hub of supply chain finance, which can provide credit guarantees for SMEs. Supply chain finance works only when the core enterprise provides a risk guarantee. In addition, the core enterprise and the SMEs can provide credit protection. In addition, the core enterprise and the SMEs maintain a long-term trade relationship. The risk elements of the core enterprise include data information security risk ($B_1$), supplier contractual risk ($B_2$), illegal transaction ($B_3$), imperfection of business process design ($B_4$), low degree of cooperation with suppliers ($B_5$), suppliers in poor financial condition ($B_6$) and unstable information platform ($B_7$).

2.3 The SMEs

SMEs are the main body of supply chain finance. As SMEs have financing needs and maintain long-term trade relations with the core enterprise. The risk elements of the SMEs include capital risk ($C_1$), market risk ($C_2$), hedge risk ($C_3$), small scale of enterprises ($C_4$), corporate profitability feebleness ($C_5$), corporate solvency feebleness ($C_6$) and corporate development ability feebleness ($C_7$).

In summary, this paper constructs the list of risk elements of supply chain finance as shown in Table 1.

<table>
<thead>
<tr>
<th>Secondary Indicators</th>
<th>Tertiary Indicators</th>
<th>Indicator Description</th>
<th>REF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Institution ($A$)</td>
<td>Uncollectible Accounts Receivable ($A_1$)</td>
<td>The financial institution's accounts receivable must be collected promptly due to the buyer's a credit or asset quality deterioration.</td>
<td>[5]</td>
</tr>
<tr>
<td></td>
<td>Crediting False Trade ($A_2$)</td>
<td>The financial institution should have examined whether the trade contract is fulfilled and whether the company uses this loophole to apply for a loan.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frustration of the Pledge Right ($A_3$)</td>
<td>The core enterprise refuses to ship the goods, the logistics company cannot receive the payment, and the financial institution cannot obtain the pledge.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Standard Bill of Lading ($A_4$)</td>
<td>The customer provides a false bill of lading, but the financial institution must detect the problem in time.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operational Process Violations ($A_5$)</td>
<td>There still needs to be improved cooperation between the financial institution, the core enterprise, and the third-party logistics enterprise.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International Business Disputes ($A_6$)</td>
<td>The financial institution's international operations face more complex and volatile uncertainties than domestic ones.</td>
<td>[6]</td>
</tr>
</tbody>
</table>
### Unreasonable Use of Financial Technology ($A_7$)

The application of financial technology has lowered the entry barrier to financing, and security is difficult to guarantee.

### Data Information Security Risk ($B_1$)

In the core enterprise, in the process of information technology operation, sensitive information is illegally obtained, tampered with, or destroyed.

### Supplier Contractual Risk ($B_2$)

The core enterprise can only deliver the products on time if the supplier fulfills the contract.

### Illegal Transaction ($B_3$)

The core enterprise is exposed to illegal transaction risks that may lead to corporate lawsuits and other problems.

### Imperfection of Business Process Design ($B_4$)

The core enterprise has some omissions or unreasonable problems in the business process design.

### Low Degree of Cooperation with Suppliers ($B_5$)

Lacking close cooperation between the core enterprise and suppliers may lead to problems such as unstable supply.

### Suppliers in Poor Financial Condition ($B_6$)

The core enterprise's suppliers need to be in better financial condition, resulting in problems such as suppliers being unable to deliver on time.

### Unstable Information Platform ($B_7$)

Some technical problems with the platform prevent companies from trading properly on the platform.

### Capital Risk ($C_1$)

Small businesses often need more funds to deal with unexpected situations, which may result in small businesses being unable to deliver their products or services on time, which in turn may lead to lost orders and loss of reputation.

### Market Risk ($C_2$)

SMEs may need help to accurately predict changes in the market and changes in demand, resulting in overproduction or underproduction.

### Hedge Risk ($C_3$)

SMEs are at risk of being unable to properly use supply chain finance tools to hedge their risks, leading to greater exposure.

### Small Scale of Enterprises ($C_4$)

Enterprises with fewer members and assets may need more resources, substantial market competitiveness, and innovation capacity.

### Corporate Profitability Feebleness ($C_5$)

Enterprises with low return on net assets and low net sales margins may need more cash flow and a lack of financial support.

### Corporate Solvency Feebleness ($C_6$)

Enterprises with low quick and high gearing ratios need help repaying debts and may face bankruptcy and other problems.

### Corporate Development Ability Feebleness ($C_7$)

The low growth rate of total assets, profit, and sales revenue, little room for future development, and bottlenecks in the development process.

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### 3. ISM Method

Professor Warfield developed the interpretative structural modeling method (ISM) in the United States, which is widely used for identifying and generalizing relationships between factors [13]. The
model simplifies complex problems by representing numerous factors in an unambiguous hierarchy, enabling decision-makers to choose the appropriate options according to their needs. ISM constructs an integrated system model based on a set of interrelated variables and finally represents this approach in a hierarchical diagram. ISM determines the relationships between factors utilizing mathematical derivation and finally gives a The advantage of the ISM approach is that the intricate relationships among the factors are sorted out and presented in a clear hierarchy.

The implementation of the ISM methodology consists of the following steps:

STEP1: Identify the set of risk elements $S$. Identify the system elements by finding literature or consulting experts.

$$S = \{S_1, S_2, \ldots, S_n\}$$ (1)

In Equation (1), $S_i$ denotes the $i$-th element of the set $S$.

STEP2: Construct adjacency matrix $A$ based on the relationship between factors. In adjacency matrix $A$, we define the value of the relationship between two factors $a_{ij}$ as: $a_{ij} = 1$ if $i$ affects $j$; otherwise, $a_{ij} = 0$; in particular, $a_{ij} = 0$ when $i = j$.

STEP3: The accessibility matrix $M$ can be calculated from Equation (2) as follows:

$$M = (A + I)^{\lambda+1} = (A + I)^{\lambda} \neq (A + I)^{\lambda-1} \neq \cdots \neq (A + I)^2 \neq (A + I)$$ (2)

In Equation (2), $I$ is the unit matrix, $\lambda \leq \text{the number of factors}$.

STEP4: All factors are divided into different hierarchies in accordance with the accessible matrix $M$. Derive the reachable set $R(S)$ and the look-ahead set $A(S)$ from the accessible matrix $M$. The look-ahead set comprises the factors and the factors that impact it, whereas the reachable set comprises the factors and the other factors that are influenced by it. The intersection set $R(S) \cap A(S)$ is the set of all factors. If $R(S) \cap A(S) = R(S)$, then the factors in $R(S)$ are located in the uppermost layer. This procedure is repeated to get the next layer until all factors are stratified.

STEP5: Draw the directed diagram. Nodes and edges express the hierarchical relationship between the above elements. The surface factors are at the top of the hierarchy, and the second layer is drawn down. Continue to repeat until the bottom. If two factors have a direct relationship, a directed line segment is drawn, and the final diagram is obtained.

4. MICMAC Method

French scholars proposed the Matrix-based Multiplication Applied to a Classification (MICMAC) Duperrin et al. in 1973. This method is used to analyze the interconnection between the elements in the system, mainly based on the interrelationship between the factors to divide the factors. It uses various relationships to reach the path and hierarchical cycle, and evaluate the degree of influence between factors. This method is often used to calculate the driving power and dependent power of various factors [14]. Its advantage is that it can provide multi-level analysis results and quickly identify the main problems and better solutions.

The implementation of the MICMAC method consists of the following steps:

STEP1: Calculate the driving power and dependent power of each factor. Obtain the driving power of each factor by summing up each row of the accessible matrix $M$ and the dependent power by summing up each column of matrix $M$.

STEP2: All factors are divided into autonomous, dependent, linkages, and independent categories according to driving power and dependent power. The driving power and dependent power of each factor in the autonomous category are both weak, which has less influence on the whole system; the dependent power of each factor in the dependent category is high, but the driving power is weak, which can have some influence on the system; the linkages category has high driving power and
dependent power, and any change in one of the factors will have a more significant impact on the other factors; the independent category has high driving power but weak dependent power, and has the most significant impact on the other factors.

5. Calculation and Analysis

5.1 ISM Calculation and Analysis

To determine the score of each element, this paper uses expert interviews and invites five experts for ISM adjacency matrix construction, and the meanings of 0 and 1 in the cells follow the rules of STEP2 in heading 3 above. The results of several expert scores were combined to obtain the adjacency matrix, as shown in Table 2.

|   | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ | $A_6$ | $A_7$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ | $B_5$ | $B_6$ | $B_7$ | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ |
| $A_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $A_2$ | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $A_3$ | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $A_4$ | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $A_5$ | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $A_6$ | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $A_7$ | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $B_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| $B_2$ | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $B_3$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $B_4$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $B_5$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $B_6$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| $B_7$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $C_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| $C_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| $C_3$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| $C_4$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| $C_5$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| $C_6$ | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $C_7$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The adjacency matrix was brought into SPSSPRO for ISM operation, the accessibility matrix was calculated separately, as shown in Table 3, and the ISM hierarchy diagram was shown in Figure 1. The 21 factors are hierarchically divided into five levels, among which the levels $L_2$ and $L_5$ contain more risk factors, and the levels $L_1$, $L_3$, and $L_4$ have fewer risk factors.
The risk factors at the surface level are the direct factors of risk, which can involve more profound factors to be prevented. Failure to uncollectible accounts receivable of financial institutions may lead to the failure to uncollectible accounts receivable of financial institutions. The situation of supply chain finance divides the risk factors into three levels, L1 and L2 as the surface factors, L3 and L4 as the transition factors, and L5 as the core factors. The risk factors at the surface level are the direct factors of risk, which can directly impact the generation of risk events in supply chain finance. The uncollectible accounts receivable is the most direct factor of risk in supply chain finance. The risks faced by SMEs, the low level of cooperation between core enterprises and suppliers, and the poor financial status of suppliers may lead to the failure to uncollectible accounts receivable of financial institutions. The situation of suppliers also affects the trade relationship between the core enterprise and the SMEs, which leads to risk for the SMEs. In particular, the financial institution's uncollectible accounts receivable the most factors, which will involve more profound factors to be prevented.

### Table 3. Accessible Matrix

| A1 | A2 | A3 | A4 | A5 | A6 | A7 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | C5 | C6 | C7 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |

### Figure 1. ISM Hierarchy Chart
The transition factors affect the surface factors and core factors directly or indirectly. The transition factors have a complex relationship and are the focus and difficulty of risk prevention in supply chain finance. The frustration of the pledge right and supplier contractual risk directly impact the financial institution's uncollectible accounts receivable. Strengthening the management of such factors can reduce unnecessary risk events.

The core factors are the fundamental factors that directly or indirectly affect other levels of factors. If the financial institution and the core enterprise pay more attention to the core risk factors, it is easier to control the risk effectively from the root. Strengthening business supervision and improving business processes can improve risk prevention to a greater extent.

5.2 MICMAC Calculation and Analysis

Based on the Table 3 accessible matrix, each risk factor's driving power and dependent power are calculated separately and mapped to the Power Map to obtain the MICMAC analysis results of the risk factors, as shown in Figure 2.

![Figure 2. Power Map](image)

The factors in the first quadrant belong to the autonomous category, and the factors in this quadrant are $B_2$, $B_5$, and $B_6$. In this category, $B_6$ has relatively strong driving and dependent power, indicating that the supplier's financial condition is related to more external risk factors. In this quadrant, driving power and dependent power are small, but it still plays a role in the top and bottom of the core factors. The relationship between them and other factors is relatively simple. Therefore, risk control strategies should be targeted to deal with them.

The factors in the second quadrant belong to the independent category. The factors in this quadrant are $A_2$, $A_4$, $A_5$, $A_6$, $A_7$, $B_1$, $B_3$, $B_4$, and $B_7$, respectively, the most fundamental factors that constitute the risk of supply chain finance. These factors have a high driving power and a low dependent power. Strengthening the management of factors at this level can minimize the possibility of risk events at the surface and transition levels. Therefore, it should be managed as a priority.

The factors in the third quadrant belong to the linkages category, where there are no risk factors, indicating that there are no risk factors with strong driving power and dependent power in supply chain finance risk.

The factors in the fourth quadrant are dependent, covering $A_1$, $C_1$, $C_2$, $C_3$, $C_4$, $C_5$, $C_6$ and $C_7$. Such factors have low driving power but high dependent power, and the occurrence of factors in the quadrant is influenced by other factors, such as the financial institution's uncollectible accounts receivable is influenced by other factors.
6. Conclusion

The ISM-MICMAC model was constructed by selecting the risk factors of supply chain finance to study the association between the risk factors and the mechanism of risk event occurrence. The specific conclusions are as follows.

1) The risks faced by SMEs, uncollectible accounts receivable, the core enterprise's low degree of close cooperation with suppliers, suppliers in poor financial condition are the surface factors that leads to the formation of risk. Crediting false trade, operational process violations, data information security risk, illegal transaction, and other factors are the core factors that leads to the formation of risk.

2) This paper classifies risk factors into the autonomous, dependent, linkages, and independent categories, and determines their mutual dependence and driving power. The financial institution's uncollectible accounts receivable, and the SMEs' all risk factors have high dependent power and low driving power, so they depend on other factors to be solved. Crediting the factors of false trade, non-standard bill of lading, the unreasonable use of financial technology, data information security risk, etc. have high driving power and are the most fundamental elements of supply chain finance risk, which deserve more attention.

References


